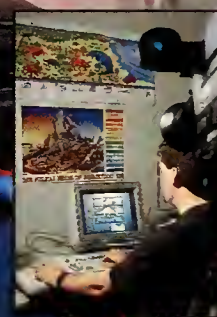
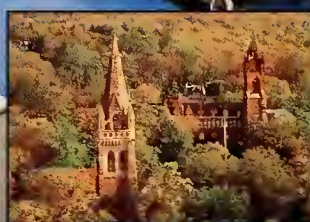
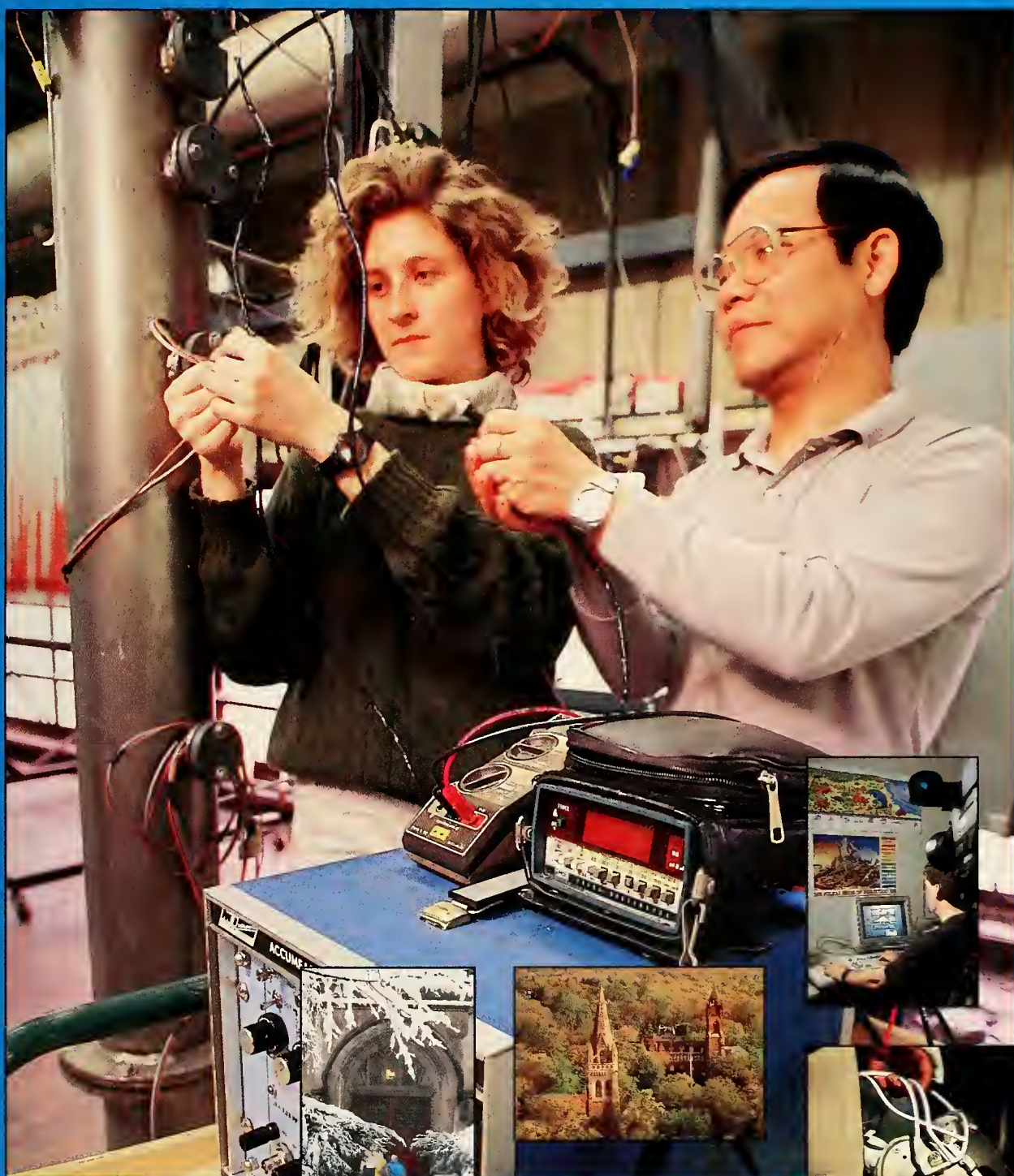


1993-94 CATALOG

LEHIGH UNIVERSITY



LEHIGH UNIVERSITY 1993-1994 COURSE CATALOG

Admission

(215) 758-3100

College of Arts and Science

(215) 758-3300

College of Business and Economics

(215) 758-3400

College of Education

(215) 758-3225

College of Engineering and Applied Science

(215) 758-4601

Graduate School

(215) 758-4280

Note: As of January 1, 1994,

Lehigh's area code will change to 610.

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Academic Calendar - *inside back cover*

Undergraduate Major Programs

The university offers the following undergraduate major programs. While most of these programs are offered as majors within a specific academic department, in some cases subjects transcend departmental lines or are emphases within a major program. Minors are available in virtually all major programs. Programs that are offered

only as minors are described under the entries for individual colleges in Section III, Academic Programs in the Colleges, and under individual departments in Section V, Description of Courses. Graduate programs are offered in many of the subjects listed. These are described in Section IV, Graduate Study and Research.

Accounting	Electrical Engineering/Engineering	Management
American Studies	Physics	Marketing
Anthropology	Engineering Mechanics	Materials Science and Engineering
Applied Science	Engineering Physics	Mathematics
Architecture	English	Mechanical Engineering
Art	Environmental Sciences	Molecular Biology
Behavioral Neuroscience	Finance	Music
Biochemistry	French	Natural Science
Biology	Fundamental Sciences	Philosophy
Chemical Engineering	Geology	Physics
Chemistry	Geological Sciences	Pre dental Science
Civil Engineering	Geophysics	Premedical Science
Civil Engineering/Geological Sciences	German	Psychology
Classical Civilization	Government	Religion Studies
Classics	History	Russian Studies
Cognitive Science	Industrial Engineering	Science, Technology and Society
Computer Engineering	Interdisciplinary Studies	Sociology/Social Psychology
Computer Science	International Careers	Spanish
East Asian Studies	International Relations	Statistics
Economics	Journalism	Theatre
Electrical Engineering	Journalism/Science Writing	Urban Studies

Academic Departments

College of Arts and Science

Arts and Architecture
Chemistry
Earth and Environmental Sciences
English
Government
History
International Relations
Journalism
Mathematics
Modern Foreign Languages
Molecular Biology
Music
Philosophy
Physics
Psychology
Religion Studies
Social Relations
Theatre

College of Business and Economics

Accounting
Economics
Finance
Law and Business
Management
Marketing

College of Education

Counseling Psychology, School Psychology
and Special Education
Leadership, Instruction and Technology

College of Engineering and Applied Science

Chemical Engineering
Civil Engineering
Electrical Engineering and
Computer Science
Industrial Engineering
Materials Science and Engineering
Mechanical Engineering and
Mechanics

Lehigh University reserves the right at any time to change the rules and regulations governing admission, tuition, fees, regulations affecting its students.

I.



Information of General Interest

Mission Statement: To advance learning through the integration of teaching, research, and service to others.

Excellence is the hallmark of a university of distinction. Excellence requires a total quality commitment, which must characterize every activity of Lehigh University.

Lehigh is an independent, coeducational university with programs in the arts and humanities, business, education, engineering, and the natural and social sciences, offering bachelor's degrees primarily to full-time, residential students and graduate degrees through the doctorate for both full-time and part-time students. Lehigh is small enough to be personal, yet large enough to provide stimulating diversity and to play important national and international roles.

Since Lehigh's founding in 1865, the faculty has emphasized the integration of the academic disciplines, combining the cultural with the professional, the theoretical with the practical, and the humanistic with the technological in a modern, liberal education that serves as preparation for a useful life. Lehigh is an intellectually unified community of learners, and in this sense Lehigh is an integral university.

Lehigh strives to earn international prominence as a university of special distinction through its integration of teaching, research, and service to society. The integrating

element of teaching, research and service is learning, which is the principal mission of all members of the Lehigh community. Our mission of advancing learning has three aspects: **Teaching.** The development of future leaders in our global society is first among Lehigh's purposes and first among our achievements. Preparation for leadership requires the best of teaching, in which both mentor and student are so deeply engaged that they become joint owners of the learning process.

Research. Lehigh is deeply committed to the creative search for new understanding of nature and human society as an essential element of the learning process. The scholarly inquiry and research of Lehigh faculty and students add value to instruction on our campus, and contribute to the distinction of our university.

Service. The special commitment of the Lehigh community to experiential learning through service to others imbues the entire university with a sense of purpose and value in the larger society. Lehigh is extensively involved in developing partnerships with industry, government and others in education and human services to meet the needs of our society.

In a societal sense, Lehigh is devoted to the concepts of unity, community, and cooperative achievement.

Lehigh believes that its graduates must develop critical thinking and effective communication as their habit; they must have both a broad understanding of human affairs and a domain of true competence; they are expected to live by a set of mature cultural and personal values, accept the virtue of work as a vehicle of service, and have the will to live and work with exceptional self-discipline.

Respect for human dignity is very important at Lehigh, a caring community deeply committed to harmonious cultural diversity as an essential element of the learning environment. In order that all members of the Lehigh community might develop as effective and enlightened citizens, the university encourages physical, social, ethical, and spiritual development as well as rigorous intellectual development.

December 31, 1991

This section includes information related to accreditation, admission, advanced placement, transfer students, tuition and fees, financial aid, campus life and academic regulations. Similar information for graduate students may be found in Section IV. The university's history, biographies of its presidents and descriptions of its buildings are found in Section VI.

Accreditation

Lehigh University is accredited by the Middle States Association of Colleges and Schools.

Both the undergraduate general and accounting programs and the master of business administration programs are accredited by the American Assembly of Collegiate Schools of Business. The engineering curricula are accredited by the Accreditation Board for Engineering and Technology. In addition, the computer science program offered in the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. Various College of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs. Programs in chemistry are approved by the American Chemical Society.

The department of theatre was accredited by the National Association of Schools of Theatre, recognized by the US Department of Education as the accrediting body for the field of theatre.

Policy of Equality

Lehigh University provides equal opportunity on the basis of merit without discrimination because of race, color, religious creed, ancestry, national origin, age, handicap, sex, sexual orientation or union membership.

Admission Guidelines

The total undergraduate and graduate enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation of the number of candidates who can be admitted each year to the various divisions of the university.

Because of the limitations on enrollment the Office of Admissions, under the leadership of the Director of

Admissions, conducts a selective review of candidates for admission. Several criteria are used in an attempt to predict a student's ability to do college level work.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

The admission policy of the university is designed to enroll students with a variety of backgrounds. The course work or units required for admission represent the equivalent of the usual four-year college preparatory curriculum with certain specific course work being required for enrollment in certain colleges within the university. Evidence of academic growth, ability to learn, and motivation are special qualities that may not be reflected in the accumulation of units. Such qualities are also considered by the admissions committee.

Minimum subject matter requirements (16 units)

English 4 units
foreign languages* 2 units
social science 2 units
laboratory science 2 units
college preparatory mathematics** 3 units
elective subjects 3 units

*Only in exceptional cases, and for otherwise well-qualified candidates, will the Committee on Admission waive the foreign language requirement for admission to any one of the three undergraduate colleges.

**Waivers of the requirement in mathematics are granted to otherwise well-qualified candidates for admission who propose to major in one of the following fields offered by the College of Arts and Science: American studies, art, classics, theater, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Students planning on enrolling in the College of Engineering and Applied Sciences must have studied Chemistry and mathematics through trigonometry, and should have studied Physics and mathematics through pre-calculus. Calculus is recommended. Students planning on enrolling in the College of Business and Economics must have completed mathematics through trigonometry, but also should strongly consider taking pre-calculus or calculus. Candidates for the College of Arts and Science preparing for a bachelor of science degree must also take math through trigonometry and candidates for a bachelor of arts degree should take additional language study beyond the two required years of foreign language study.

Minimum course work requirements can be misleading since most students who gain admission to Lehigh University exceed the minimum course work. Strength of preparation can be difficult to assess since each individual comes from a different background. However, the Committee on Admissions will look for things such as: (in no particular order)

- Rank or relative rank in class
- How the student's grades compare to those of his or her classmates at that particular school
- Evidence of improvement or deterioration in the grades during the secondary school career with particular attention paid to performance in senior year courses
- The quality of performance in courses that relate to the students selected area of study
- The difficulty of courses taken with special attention paid to courses which are recognized as being accelerated by national academic organizations
- Comments and recommendations from the principal, headmaster, guidance counselor, or other professional educators within the school system
- Performance on standardized testing
- Co-curriculum/work experience with particular emphasis placed on demonstrated leadership

Entrance Examinations

Each candidate for admission to the freshman class is required to write either the Scholastic Aptitude Test (SAT) or the American College Test (ACT). It is highly recommended that the student request that his or her scores be forwarded to Lehigh (CEEB code 2365) directly. It is not the responsibility of the high school guidance office to forward the results. If during the evaluation process it is discovered that the test results are missing, the student will be notified by mail or phone. Unnecessary delays in the decision making process can result if the committee does not have the scores.

The Committee on Admissions recommends that students take the exam in the junior year and again as early in the senior year as possible. In the evaluation process, the highest score in each category will be used regardless of the test date.

Achievement Tests: Each candidate is required to write three College Board Achievement tests. The Committee on Admissions will make an admission decision without the results from these tests, but the tests are required for matriculation. Students should understand that for some students these tests can help their credential package. The tests required vary by college and are as follows:

College of Arts and Science. English with or without the essay and two other exams. Candidates for science majors must include the Math Level 1 or Math Level 2 as one of the two. Candidates for majors in a foreign language should include a test in the language of study as one of the two unless they plan to write the Advanced Placement exam in that subject.

College of Business and Economics. English with or without the essay, Math Level 1 or Math Level 2 and any other exam.

College of Engineering and Applied Science. English with or without the essay Math Level 1 or Math Level 2, and either the Chemistry or Physics exam.

The exams may be written as late as May of the Senior year but again the students should be aware that the results may help their candidacy.

Test information and applications may be secured from high school guidance offices or the College Board at either of the following addresses: P.O. Box 592, Princeton, N.J. 08541, or 1947 Center St., Berkeley, Calif. 94704. Candidates writing tests outside the United States should direct their correspondence to the Princeton address.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America, and Australia).

As with other standardized testing, the candidate has the responsibility to have the results sent to Lehigh.

Recommendations

The Office of Admissions requires, as part of a candidate's file, a letter of recommendation from the guidance counselor, principal, or headmaster from the candidate's school. One teacher recommendation may also be included but is not required. Such recommendations should address the candidate's other qualifications such as health, emotional stability, intellectual motivation, social adjustment, participation in school activities, and established habits of industry and dependability.

Interviews

Prospective freshmen and their parents are highly encouraged to visit Lehigh and participate in a campus tour and to meet with an admissions officer for a personal interview. No appointment is necessary for a campus tour, but interviews should be scheduled by appointment. A call to the Office of Admissions is recommended because the schedule of tours and interviews can change several times during the year as the academic calendar changes. During the visit to our campus it is often possible to meet with faculty, coaches, or other professional staff of the university.

The Office of Admissions is open for interviews most weekdays from 9:00 am to 11:15 am and from 1:15 pm to 4:15 pm. Tours are conducted according to the availability of tour guides, but are usually available five times a day during the school year. Some Saturday morning tours and interviews are available during the fall and winter, but these time slots fill very quickly and students are encouraged to reserve a spot as soon as possible. No interviews are granted during the February 15 to March 31 period when the staff is reading files, although exceptions can be made for persons traveling great distances.

In certain cases an interview may be required if, in the opinion of the Director of Admissions, the additional information gained in an interview would be helpful in making the correct decision regarding admission. In such cases, the candidate will be notified of our request.

How to Apply

Students may secure applications by writing to the Office of Admissions, 27 Memorial Drive, West, Lehigh University, Bethlehem, Pa. 18015, or by telephoning (215) 758-3100. Students may also use the Common Application available from school guidance counselors. The Common Application is accepted as the equal of the Lehigh application.

Applications should be filed according to the following deadlines:

- December 1—Early Decision I
- December 1—Medical College of Pennsylvania 6 year BA/MD Program
- January 1—Penn-Dental 7 year Dental Program
- January 15—Early Decision II
- February 15—Final Application deadline

Each application must be accompanied by an application fee of \$40. This fee is non-refundable and does not apply towards the tuition fees. Waivers of application fees are accepted when forwarded on the appropriate forms from the school guidance office. Students for whom the application fee is a hardship should consult the guidance office at their school.

Early Decision

The university will act on early decision applications received by the appropriate deadline. Our program is a binding early decision plan which means that the student, parents, and guidance counselor must sign an Early Decision Request form to confirm that they understand that if the student is accepted, and the financial aid package is appropriate, the student is expected to accept our offer and withdraw all other applications. Students applying early should have been to campus for an interview and should be sure that Lehigh is their first choice school. Students who meet the December 1 deadline will be notified before

December 31 and those who meet the January 15 deadline will be notified around February 1. It is understood that the student will continue a satisfactory level of academic performance throughout his or her senior year.

The early decision plan is not for everyone. It is for the student who has been early and active in their college search, and is sure that they want to attend Lehigh. When reviewing an early decision application the committee will defer a decision on any candidate when there is insufficient information to make an early decision. It is also possible that a student may be denied admission. The Committee will give early decision applicants some slight advantage in borderline cases because of the commitment of applying early, but students must still present a strong record.

Early decision candidates who have filed the Early Version Financial Aid Form and prior year tax forms will be notified approximately three weeks after the decisions on admission are made by the Office of Admissions. All other financial aid forms must be filed by the deadline indicated on each application.

Admission and Deposit

Notification of admissions decisions is made by mail between March 15 and April 1. Once a student has been admitted he or she may secure a place in the entering class by notifying the university that they intend to enroll at Lehigh and by forwarding the appropriate admissions deposit. This fee is applicable towards the tuition and room and board fees for the fall term. Students who fail to enroll or withdraw after depositing will forfeit their deposit.

Transfer Students

Each January and August students who have attended another college or university are admitted with advanced standing. Candidates for transfer admission must meet the high school subject matter requirements prescribed for entering freshmen, but entrance examinations are not required. The academic performance at the college level is the primary focus when giving consideration to admission.

Candidates who have been dropped for poor scholarship, or are not in good standing, or have been released for disciplinary reasons are not eligible for admission.

Each candidate must submit an official transcript from each institution attended. An admissions decision cannot be made without this information. Students wishing to enter in the spring should apply not later than November 1 and applicants for the fall semester should have their application in by June 1. Applications may be obtained by writing to the Transfer Section, Office of Admissions, 27 Memorial Dr., West, Lehigh University, Bethlehem, Pa. 18015 or by calling (215) 758-3100.

Students are encouraged to take an active role in seeing that the various parts of the student's admission packet have arrived at the university. Decisions are made as soon as possible after the application is complete. Soon after, the student will be notified by the Registrar as to how many credits Lehigh will grant to the student in advanced standing.

Housing: Due to the demand for residence hall housing, the university is unable to automatically guarantee housing to transfer students. Although it is not possible to predict exactly how many housing spaces may be available at the start of any given semester, some space is available in most semesters. Contact the Office of Residential Services, Rathbone Hall, Lehigh University, 63 University Drive, Bethlehem, Pa. 18015 or by calling (215) 758-3500. This office also can provide information about off campus housing. Fraternities and Sororities often have room for members or boarders. Information on this option may be obtained through the Office of Student Life, Coordinator of Greek Affairs, University Center, 27 Trembley Drive, Lehigh University, Bethlehem, Pa. 18015 or by calling (215) 758-4157.

Advanced Placement

The university offers capable students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the Advanced Placement Tests offered by the College Board.

Students who achieve advanced placement are afforded three major advantages. First, they commence study at Lehigh at a level where they will be academically comfortable. Second, students who qualify for college credits may be graduated at an earlier time—with resulting savings in time and tuition outlay. Third, qualified students may, in the Lehigh senior year, enroll for a limited amount of work for graduate credit.

Entering freshmen who ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement. Examination grades range from a low of 1 to a high of 5.

Some departments noted below offer examinations during Freshman Orientation to students who studied college-level subjects in secondary school but did not write the advanced placement tests. Entering freshmen wishing to write an examination in any Lehigh course should notify the office of admission in writing prior to August 1. The student should specify the number and title of the course. Students who receive credit on the basis of advanced placement grades need not write Lehigh tests to confirm the credit granted.

Current practice at Lehigh is as follows:

Art and Architecture. Six credit hours for Art 1 and Art 2 are granted to students who earn a grade of 5. Three credit hours for Art 1 are granted for those students who earn a grade of 4. Those students who earn grades of 5 on the Advanced Placement Studio Art Examination receive three credit hours for Art 7.

Biology. Three credit hours for EES 31, Introduction to Environmental/Organismal Biology, given to those who earn grades of 4 or 5.

Chemistry. Eight credit hours for Chem 21, Chem 22, and Chem 31 are granted to students who earn a grade of 5. Those students who earn a grade of 4, or who score 750 or higher on the chemistry achievement test, are granted five credit hours for Chem 21 and Chem 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for Chem 31.

Computer Science. Students receive three semester credit hours for CSc 11 for a grade of 3. Those students who earn grades of 4 or 5 receive four credit hours for CSc 17 instead of CSc 11.

Economics. Students will receive three credit hours for each of the microeconomics and macroeconomics exams in which a score of 4 or better is awarded.

English. Advanced placement and six credit hours are given for freshman English to students who earn a grade of 5. Students who receive a grade of 4 or who have a score of 700 or higher on the verbal section of the Scholastic Aptitude Test or the English Composition Achievement Test receive three hours of credit in freshman English; these students complete the six-hour requirement by taking an English course suggested by the department. Students whose SAT Verbal Aptitude Test or English Composition Achievement score between 650 and 699, or who have received a grade of 3 on the advanced placement test may apply to the department for a special examination given during Freshman Orientation, which if completed successfully, will result in three hours of credit for Engl 1.

Government and Politics. Three semester credit hours for Government I are given to students who earn grades of 4 or 5.

History. Students who earn grades of 4 or 5 on the American History Test receive six semester hours of credit for Hist 9, 10, Survey of U.S. History I, II. Students who earn grades of 4 or 5 on the European History Test receive three semester hours of credit for Hist 12, Survey of European History II.

Latin. Students receive three semester hours of credit for

a grade of 4 or 5 in the Vergil examination; those who successfully write in more than one area (e.g. Vergil and lyric poetry) receive six hours of credit.

Mathematics. Four semester hours of credit for Math 21, Analytic Geometry and Calculus I, are granted to those who earn grades of 4 or higher on the Calculus AB examination. To those who earn a grade of 4 or higher on the Calculus BC examination, eight hours of credit are granted for Math 21 and Math 22, Analytic Geometry and Calculus I and II. Credit for Math 21 and 22 or both may also be earned by passing the examination offered by the Mathematics Department during Freshman Orientation. This examination may be taken by students regardless of whether they have taken the advanced placement examination or not.

Modern foreign languages. Students receive three semester hours of credit for grades of 4, and six hours of credit for grades of 5 on the advanced placement tests. Those who write the achievement tests and score 600 and above receive three hours of credit; 700 and above receive six hours of credit. The maximum number of credits given is six and will be assigned intermediate level course credit in the appropriate language. Those students receiving grades of 4 or higher on the French or Spanish literature examinations will receive 3 credits for French or Spanish 151.

Music. Three semester hours of credit for Mus 20 are given to those students who earn a grade of 3 or higher on the advanced placement test in Music: Listening/Literature of Music: Theory.

Physics. Four hours of credit are given for Physics 11, Introductory Physics I, for a grade of 5 on the Physics B examination or a grade of 4 on the mechanics section of the Physics C examination. If a student receives credit for Physics 11, four hours of credit will be given for Physics 21, Introductory Physics II, for a grade of 4 on the electricity and magnetism section of the Physics C examination. If a student wishes to be considered for credit for Physics 12 or 22, Introductory Physics Laboratory I and II, he or she should see the chairperson of the physics department with evidence of laboratory experience. A test is offered during Freshman Orientation.

Psychology. Four credit hours of Psyc 1 are granted to students who earn a grade 4 or 5.

International Baccalaureate. Students who earn the international baccalaureate are granted credit in higher-level or advanced subjects in which they earn scores of 5 or higher.

Estimate of Expense for Undergraduates

The operating expense of Lehigh University is supported principally by three areas of income: tuition and fees; endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and it strives to maintain a program of high quality instruction while recognizing that there are limitations on what families can afford to pay. Costs will vary somewhat from student to student depending upon the various options chosen.

Tuition, Room, and Board

There are three major plans that cover the major expense associated with university attendance. These are as follows:

The tuition plan. The university provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of most athletic events, basic treatments in the Health Center, libraries, and laboratory services. An additional \$250 fee is charged to all students enrolled in the College of Engineering and Applied Science or with a declared major in natural science. The full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.

The residence halls plan. A variety of living arrangements

are available. The university provides housing for 2,000 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within three basic categories, with rates associated with the category level. In order to guarantee a space within a residence halls unit, a \$200 deposit is required for each semester. This deposit is credited toward the room charge for the respective semester. For entering freshmen, the deposit is not refundable if they make other plans. For returning students, the fee is either full or partially refundable based upon a published schedule.

The board plan. Four board plans are available. The basic Any-19-Meal Plan is required for all freshman residents. Upperclass students living in residence halls have the option of participating in the Any-10-Meal Plan. Students residing in fraternities, campus apartments, or any off-campus facilities are eligible to participate in any of the plans. The Any-7-Meal Plan is for Centennial I sororities. Subscription to special program meals is required of residential college members.

Tuition and Fees

All charges and fees are due two weeks prior to the start of classes each semester. On a per-term basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date are subject to a late-payment fee. All figures given are for the academic year (two semesters).

Tuition, 1993-94 \$17,750

Residence Halls

Category I (Dravo, Drinker, Richards, and McClintic-Marshall)	\$2,800
Category II (Centennial II, Warren Square)	\$3,160
Category III (Trembley Park, Brodhead House, and Taylor College)	\$3,380

Board

Any 19 meals per week*	\$2,340
Any 10 meals per week*	\$2,060
Any 7 meals per week*	\$1,450
Any 5 meals per week*	\$1,260

*Each meal plan includes \$100 South Mountain Gold credit.

Based upon the above charges, most freshmen are normally billed the tuition rate along with the Category I or II room fee and the 19 board plan. The total cost for the three areas would be \$22,890 for the 1993-94 academic year.

Other Fees (applied to prevailing circumstances)

Per credit charge for credit and audit	740
Engineering and Science Fee (for specified students)	250
Application fee (for undergraduate admission consideration)	40
Late preregistration	50
Late registration	50
Late application for degree	25
Examination make-up (after first scheduled make-up)	10
Late payment (after announced date)	50
Returned check fine	20
Key penalty (non-return), residence halls	10
Key duplicate, building door, residence halls	5
Access card duplicate, residence halls	10
Lost or non-return room key/lock change, residence halls	25
Identification card (replacement)	10

The university reserves the right at any time to amend or add charges and fees, as appropriate, to meet current requirements. Fees applicable to the 1994-95 academic year will be announced no later than January, 1994.

Other Expenses

A student should plan to meet various other expenses. These expenses include the purchase of books and supplies from the Lehigh University Bookstore located in Maginnes Hall.

Necessary purchases supporting one's academic program should average approximately \$500 per year. The bookstore carries basic goods for students' needs. A student should also plan an allowance to handle personal and travel expenses.

Plan of Payments

An itemized statement of charges is mailed from the bursar's office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements.

Persons desiring a payment plan can elect participation in the university's educational payment plan which provides for the payment of tuition, room, and board over ten months. You may also elect to participate in the Richard C. Knight Plans. The university also offers a plan under which enrolled undergraduate students can pre-pay more than one year of tuition at current rates. Complete information is available from the bursar's office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment.

Students attending the university under a provision with a state board of assistance or with financial aid from other outside agencies must provide complete information to the bursar's office if assistance is to be recognized on the semester statement.

Refunds of Charges

Tuition refunds. A student in good standing who formally withdraws (within the first eight weeks of a semester) or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to the start of the semester	100%
during first calendar week	80%
during second calendar week	70%
during third calendar week	60%
during fourth calendar week	50%
during fifth calendar week	40%
during sixth calendar week	30%
during seventh calendar week	20%
during eighth calendar week	10%

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar's Office.

In the event of the death of a student, tuition will be refunded in proportion to the semester remaining.

Tuition Credit/Suspension. A student who is suspended from the university for disciplinary reasons will be eligible for a tuition credit toward the semester immediately following the period of suspension. The amount credited will be based on the regular tuition refund schedule and calculated on the tuition rate in effect during the period of suspension.

The date used to calculate the tuition credit will be the date of the incident that resulted in the suspension. Under no circumstances will a tuition refund be provided to students who are suspended for disciplinary reasons.

Summer Sessions. Students who preregister for a summer session by the end of April will receive an invoice for their tuition. Those who do not receive an invoice are expected to make payment at the time of registration. Registration will not be permitted until all charges are paid. Students in good standing who formally withdraw or reduce their course enrollment within the first four weeks of a summer term will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to start of summer session	100%
during first calendar week of summer term	80%
during second calendar week	60%

during third calendar week	40%
during fourth calendar week	20%

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar's Office.

Because of the short time involved, no refunds for tuition charged in the one-week workshops will be made after the first day of class.

In the event of the death of a student, tuition will be refunded in proportion to the fraction of the summer term remaining at the time of the death.

Residence hall refunds. Residence hall rooms are rented on an annual basis only. A student who signs a room contract is expected to occupy a room for the full academic year. A student who forfeits a room reservation in the Fall Semester and returns to the university in the Spring Semester is still obligated for room rental charges for the Spring Semester, if such facilities are available. An advance deposit of \$200 for each semester is required to hold a room for the respective semester. This deposit is nonrefundable to entering freshmen and either full or partially refundable to upperclass students based upon specific criteria and a published refund schedule. Prior to registration, refunds are made in full in the event a student does not register because of illness, injury, or death, is dropped from the university due to academic reasons, attends a university approved study abroad or co-op program, graduates or voluntarily withdraws from the university. After registration, prorated refunds are granted based on separation from the university due to illness, injury, or death. In the event of voluntary withdrawal, a prorated refund is possible only with the provision that the lease can be transferred to another student for whom no other university accommodations exist. Prorated refunds are based upon the date the room keys are returned to the Office of Residential Services. Any student suspended or expelled from the university will not be granted any room refund.

Refunds for board plans. Board refunds are made in full in the event a student does not register because of illness, injury, death, is dropped from the university due to academic reasons, attends university approved study abroad or co-op programs, or graduates. Board Plan refunds after the start of the semester are prorated based on the number of unused days remaining in the board plan at the time the plan is discontinued and the Bursar's Office is notified in writing. Prorated refunds may be granted based on separation from the university due to illness, injury, or death or voluntary withdrawal from the University.

Board plans may be changed within the requirements of the living area up to the 10th day of class of each semester. Changes outside of the required board plan or after the 10th day of class for reasons such as medical condition, etc., must receive approval from Office of Residential Services. If such changes are approved, cost adjustments will be processed on a prorata basis according to an established refund schedule.

Any student suspended or expelled from the university will not be granted a board plan refund. A student suspended may receive a prorated board plan credit toward the semester immediately following the period of suspension.

Adjustments to financial aid. The office of financial aid is responsible for determining the appropriate redistribution of charges and refunds when students are in receipt of financial assistance. These decisions are made on the basis of university, federal, and state agency regulations. Adjustment procedures, where financial assistance (including GSL and PLUS loans) is concerned, are on file in the office of financial aid.

Financial Aid

The University is deeply committed to providing need-based financial aid. Nearly 50% of our freshman classes now, and in the future, will receive financial aid awards.

Renewal of financial aid is based on continuing "need" and a minimum academic average of 2.0. (Students entering

Lehigh prior to the 1990 fall semester have a 2.4 renewal average requirement.)

Lehigh expects that all families of its students will make every effort to pay tuition and other educational expenses. The aid program is focused to measure the dollar difference between the cost of attendance and the amount of money the family can be expected to contribute towards that cost. That difference is called "financial need" and represents financial aid "eligibility." Most of Lehigh's funds are awarded on the basis of this "eligibility", the principal exceptions being explained below.

We currently enroll at least 45 percent of the freshman class with university scholarships ranging, according to need, from \$500 to \$20,500. An additional 5 percent will enroll with aid from sources other than Lehigh, including state and federal grants, ROTC scholarships, aid from private sources, and education loans.

The basic forms of financial aid are employment, repayable loans and "gift aid", which are non-repayable forms of aid that can be called either scholarships or grants. **Employment** provides money for books and personal expenses, and is paid through monthly payroll checks as a student submits timesheets for hours worked. **Loans** are borrowed dollars, from one or more resources, that are repayable at low interest rates after the student ceases to be enrolled on at least a half-time basis. **Grants (or scholarships)** are not repayable. Most are awarded on the basis of "need" and are renewable on the bases of both continuing "need" and some stated minimum academic advancement criteria.

Additional sources of aid are state agencies, employers, and various clubs, churches, religious and fraternal organizations, and foundations. High school guidance counselors are able to provide information on local aid programs. Students are expected to apply for all possible kinds of outside financial assistance, especially the Pell Grant and state grants. Students are expected to take maximum advantage of outside sources to enable Lehigh to spread its own funds farther and to limit student borrowing.

Application Procedures

Families of freshmen desiring financial aid will find a university financial aid application in the viewbook provided by the Office of Admission. This application should be returned directly to the Office of Financial Aid by February 15. It is also necessary to file the *Free Application for Federal Student Aid* and the *Financial Aid Form* with the College Scholarship Service between January 1 and February 15. (Understand that this means these forms must have been received by CSS on or before February 15.) These forms are normally available in guidance offices in December. All forms must be completed in their entirety. Incomplete forms will not be reviewed.

Pennsylvania residents are advised to also file the *Pennsylvania Aid Information Request* as a means of applying for a state grant, which is expected of all applicants for university aid.

All applicants should request that the College Scholarship Service send their analysis of the application to Lehigh. The Lehigh code number is 2365. If the student is granted aid from Lehigh for 1994-95, a signed copy of the parents' and student's 1993 IRS Form 1040, with schedules and W-2s, must accompany the acceptance. If possible, the tax returns should be sent as soon as prepared to help with the review of the FAF. Aid awards are not final until the FAF and Form 1040 are compared. Award adjustments are made where differences in income and assets exist.

Additional forms are required of students whose parents are **divorced or separated**. The student applicant and the parent, with whom the student resides (i.e., the custodial parent or "at home" parent), complete the FAF. If that parent has remarried, the stepparent's information must also be included. The other (non-custodial) parent is asked to complete the *Divorced/Separated Parent's Statement*. Lehigh requires this statement and will mail it to the applicant soon after receiving the FAF, although the family may request this form in advance.

Parents who are self-employed, or who own an income-

producing farm, must file a *Business or Farm Supplement*, available from the Office of Financial Aid.

Renewal of aid. It is necessary to reapply for financial aid for each year of study. Applications and filing instructions are available in mid-February in the Office of Financial Aid, or as otherwise posted.

Upperclassmen file the FAFSA and FAF with CSS by April 1. A Lehigh application form must also be completed and returned to the university's office of financial aid by April 1, accompanied by a signed copy of both the parents' and the applicant's 1993 IRS 1040 (with all schedules filed and W-2's), as well as those additional forms required for special circumstances, such as the *Divorced/Separated Parent's Statement*. Upperclass applications are not reviewed until the FAFSA, FAF, Lehigh application and income tax forms are received.

In addition, to receive any type of aid a student must make satisfactory academic progress each year. University policy on satisfactory academic progress is available in the office of financial aid. Recipients of Lehigh grants and scholarships are expected to achieve at least a 2.4. Beginning with the freshman class entering in August 1991, the renewal average is a minimum of 2.0. Students on academic or disciplinary probation are ineligible for university scholarship aid during the period of their probation. Students not maintaining satisfactory progress, as defined by Lehigh, are ineligible for all forms of federal aid, including loans and employment. Appeals based on extenuating circumstances are submitted to the Committee on Undergraduate Financial Aid.

Eligibility for financial aid is determined by calculating the amount a family can contribute to the cost of attendance based on income, assets, family size, number in college, and other factors. The expected contribution is then subtracted from the cost of attendance to yield "financial need."

In general, a student might be expected to have some need when the family's annual income and number of tax dependents (usually children) are as follows:

with one child at home	\$55,000
with two children at home	\$65,000
with three children at home	\$75,000
with four children at home	\$90,000

The figures above are for income before taxes and deductions, allowing for normal savings and home equity, with one child attending college. When more than one child is in college, the likelihood of financial aid is increased. Families with incomes as high as \$115,000 are able to establish financial need if, for example, they have three children, all enrolled in independent universities like Lehigh.

Sources of University Aid

Several forms of university-funded aid, based on need and merit, are available.

Lehigh University scholarships. Funds are budgeted from general income to provide awards covering the tuition charges in whole or in part.

Sponsored scholarships. Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has 190 such sponsors, with awards ranging from \$300 to full tuition.

Endowed scholarships. Income from invested gifts to the university makes these scholarships possible. The university has 300 such funds, half of which are for general, unrestricted use. Most of the others are restricted by curriculum or geographic criteria.

Geographic Restrictions: Pennsylvania, New Jersey, Delaware, Maryland, Ohio, Massachusetts, Virginia, Colorado, Texas, Georgia, North Carolina, Tennessee, Missouri, Kansas, Richmond, VA, Kansas City, MO, Jackson County, MO, Johnson County, KS, Hammononton, NJ, Allentown, PA, York County, PA, New York City, NY, Baltimore, MD, Western, PA.
College of Arts and Sciences: Geology and Geological Science, Premedical Science, Journalism and Science Writing.
College of Business and Economics: Accounting, marketing, economics.

College of Engineering and Applied Sciences: Applied mathematics, civil engineering, chemical engineering and chemistry, computer science, electrical engineering,

industrial engineering, mechanical engineering, metallurgy, physics and engineering physics.

Miscellaneous: Musicians (brass instruments); Gryphons; employees of U.S. Steel, Milton Roy Sheen, and Alperin Co.; members of certain fraternities.

Merit scholarships. Lehigh is a collegiate sponsor of the National Merit Scholarship program. Scholarships ranging from \$750 to \$2,000 per year may be awarded to Merit finalists selecting Lehigh as their first-choice college, and who are not also receiving another form of National Merit scholarship.

Athletic awards. Alumni Student Grants are awarded on the basis of financial need and exceptional athletic talent as evaluated by the department of intercollegiate athletics. Grants are supported by annual alumni contributions. ASG recipients file the FAFSA and FAF annually to determine the amount of their grant eligibility. In addition, there are a number of restricted endowed funds for use with intercollegiate sports participants. Alumni Student Grants replace the loan and employment portion of a financial aid package.

University tuition loans. Parental endorsement is required on the promissory note. Repayment begins three months after graduation or withdrawal from the university, until the loan principal and interest are repaid. The minimum monthly repayment rate is \$50 plus interest, which is 7 percent per annum, accruing only during the repayment period. Deferment is available for students who return to school at least half-time. Other deferments are available for students who are in the military, VISTA, or Peace Corps, up to a maximum of three years; or those who are experiencing undue hardship.

Lehigh maintains these loan funds to be used to supplement or replace other types of educational loans. The guiding factor in awarding university loans is that the combination of loans (federal, state, and institutional) shall not exceed one-half the cumulative tuition to be paid through the award period. If, for example, the total tuition over three years amounted to \$60,000, a university loan would not be offered if total borrowing exceeded \$30,000.

Loan-cancellation awards. This unique Lehigh award is used as an aid alternative for students whose academic average is not sufficiently competitive for scholarship consideration. L-C begins as a loan, with the same terms as Lehigh loans. The specified average must be earned during the term of this award for the loan to be cancelled and replaced by a scholarship. If not cancelled, the loan is repayable according to the terms for university tuition loans.

Availability of jobs

Students may receive an employment allocation as part of their aid package. Pay rates range from the federal minimum wage to \$6.25 per hour. Jobs are available throughout the university, and are funded through federal and university sources.

Earnings from employment, *other than work-study/work opportunity*, will be included as "income" in calculating financial aid eligibility for the next year.

Aid from the government

Lehigh University is an eligible participant in these federally-funded student aid programs:

Direct entitlement programs (where the government directly, or through commercial lenders for loan programs, provides the necessary funds):

Federal Pell Grants

Federal Stafford Student Loans

Federal Unsubsidized Stafford Student Loans

Parent Loan for Undergraduate Students (PLUS)

Supplemental Loans for Students (SLS)

Campus-based programs, where the University makes the awards based on the dollars available:

Federal Supplemental Educational Opportunity Grants

Federal Perkins Loans

Federal Work-Study

Details on these programs are available through the

financial aid office. Particulars on the loan programs are available from participating lenders.

ROTC scholarships. The Department of Military Science awards scholarships valued at 80% of Lehigh's tuition in addition to an amount to cover course-related books and a \$100 per month stipend. Scholarships are available after the freshman year. Recipients incur an obligation to serve on active duty as commissioned officers.

Checklist for Financial Aid

1. Submit the Lehigh application for undergraduate financial aid. Be sure to complete all questions.
2. The *Free Application for Federal Student Aid* must be received by the College Scholarship Service (or, for Pennsylvania residents, by PHEAA), by February 15 to be considered on time.
3. The *Financial Aid Form (FAF)* must also be received by CSS on or before February 15 to be considered on time. Use CSS college code 2365 in requesting that your information be sent to Lehigh.
4. Submit the appropriate state grant application, especially if you are a resident of Pennsylvania, Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, or West Virginia—states from which our students have brought scholarships.
5. Submit signed copies of the 1993 IRS form 1040, (all pages, schedules and W-2s), filed by student and parents. Income statements for those who will not file a 1040 are available from the Office of Financial Aid.
6. Check to be sure your social security number is correctly listed on all forms. If you do not have a number, apply for one and notify Lehigh as soon as it is received.
7. For your records, photocopy all forms filed for financial aid purposes.
8. *Transfers only:* Be sure to have your previous college(s) complete and forward the Financial Aid Transcript.

Campus life

Approximately 70 percent of all undergraduate men and women live on campus. Campus living facilities include traditional residence halls, apartments, suites in a multi-story building, or residence in fraternity houses or sorority units. Physical facilities are also described in Section VI.

Residence Halls

The offices of Residential Life and Residential Services at Lehigh University are committed to providing quality housing and educational services to its resident students. Lehigh firmly believes that living in a residence hall allows students to become members of a special community, offering the opportunity to live with and learn from a diverse group of people. Efforts are made to integrate academic and out-of-the-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

More than half of Lehigh undergraduates live in university residence halls. The university has nine principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, or suite arrangements, and apartment units, are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, Creative Arts House, Umoja House (African-American/Hispanic Cultural), Community Service Volunteer House, traditional-style living (in buildings with corridors), and

suite/apartment-style living.

To help facilitate and maximize a student's residence experience, approximately ninety staff members of the office of residence life live in the residence halls. On every hall there is a student staff member, a Gryphon, who provides assistance in personal and academic matters, refers students to other offices where appropriate, helps mediate conflicts, and develops educational, social, and recreational programs. In addition to the student staff, graduate hall directors and a full-time professional staff member live in the residence halls thus providing additional resources for students.

In every residence hall there are also House Councils that are part of the larger Residence Hall Association. Participation in the Residence House Council provides a chance to develop leadership, programming, human relations, and budgeting skills. It is a vital and active organization, whose prime focus is to help fund residence hall programs, to assess students' opinions on issues affecting them, and to develop many service-oriented programs to aid resident students in their stay on campus.

Currently, the demand for upperclass campus housing is competitive. The Office of Residential Services uses a lottery to provide for fair and equitable distribution of available housing among upperclass students. The lottery is scheduled early in the spring semester. Those students who are guaranteed housing pay a \$200 deposit to hold the space for the following academic year.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodation in the residence halls must return this application-contract promptly. Priority of assignment is based on date of receipt of this application. A nonrefundable advance deposit of \$200 must accompany the application and will be credited to the fall semester room charges. Normally, freshmen are informed of their room assignment and other information in early August by the Office of Residential Services.

Fraternities and Sororities

The university has one of the strongest Greek systems in the nation. The continued strength of this system is due in part to the efforts of the Interfraternity Council, Panhellenic Council, the Greek Alumni Council, the Office of Residential Services, the Office of Student Life, and the Fraternity Management Association to improve the quality of fraternity and sorority life through membership, leadership, social, educational, housing, and financial management training.

Greek life is an attractive alternative among the residence options at Lehigh. Each fraternity or sorority is a relatively small, close-knit community. These groups determine their own goals, manage their own houses and business affairs with the assistance of the Office of Residential Services and the FMA, conduct their own social, philanthropic, and athletic activities, plan their own meals, and select their own membership. Because they are largely self-governing, these organizations offer numerous opportunities for student involvement and leadership.

The twenty-seven fraternities and eight sororities form a larger Greek community comprising approximately 50 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and Panhellenic, they determine policies and organize social, philanthropic, and educational activities for the Greek community as a whole. In cooperation with the Forum, Student Activities Council, Residence Halls Council, and the office of Student Life, the I.F.C. and Panhel also help to develop programs and policies for the wider university community.

There are eight sorority chapters at Lehigh. They are housed in the Centennial I complex on the South Mountain Campus and one in Parkside House and one in Overlook House located in Sayre Park. The sororities are Alpha Chi Omega, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Delta Gamma, Delta Zeta, Gamma Phi Beta, Kappa Alpha Theta.

Twenty-four of the fraternities are located on campus in

Sayre Park. The remainder are located near the campus. The fraternities are Alpha Chi Rho, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Chi, Delta Phi, Delta Sigma Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Delta Theta, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Pi Kappa Alpha, Pi Lambda Phi, Psi Upsilon, Sigma Chi, Sigma Nu, Sigma Phi, Theta Chi, Theta Xi, and Zeta Psi.

The University Forum

The Lehigh University Forum is a unique deliberative body whose purpose is to promote the welfare of the university and attainment of a true sense of community by bringing into discourse students, faculty, and administration.

A restructuring process, completed in 1988, resulted in a simplified Forum committee structure as well as the creation of a Student Senate which deals with issues pertaining solely to students.

Its membership includes elected representatives of the student body and of the faculty, and members of the administration (including the president, provost, vice president for student affairs and dean of students).

Five Forum representatives—three students and two faculty members—attend meetings of the board of trustees. Assured of access to the information upon which administrative decisions are based and free to inquire into any aspect of university operations, the Forum affords faculty and students a voice in university affairs equaled at few institutions.

Many non-Forum students also work actively on subcommittees, and in some cases serve as chairpersons. This participation provides valuable background and experience for later candidacy to the Forum or other elective positions.

The Forum also appoints student members to certain standing committees of the faculty and certain ad-hoc university committees when invited.

All meetings of the Forum are open to the university community, with the right to address the Forum provided to any person desiring to do so.

The Forum office is located in Packer Hall, the university center, and students are invited to come in to discuss any aspect of university government.

Religious Activities

The Religious Program is under the general supervision of the university chaplain. The chaplain participates in the ceremonial life of the University and conducts special university worship services throughout the year. All worship services are interdenominational, with some being inter-religious. Roman Catholic masses are held regularly. The Newman Center can be contacted for a schedule of services.

Lehigh University is non-denominational. Packer Memorial Church, dedicated in 1887 in honor of the University's Founder, Asa Packer, continues to be the center for campus worship services.

The University Chaplain works with representatives of campus religious groups of all faiths and assists students in planning religious life programming. The chaplain's office sponsors an Oxfam Fast in November, a Community Service Desk that helps coordinate volunteer services on campus, and a "Films for Discussion Series." In addition to providing pastoral counseling, supporting religious groups, and helping bring speakers to campus, the chaplain seeks to provide leadership to the university on religious and ethical issues.

Over fifteen religious groups on campus provide opportunities for religious fellowship. The groups include the Newman Association for Roman Catholic students under the guidance of a resident priest; the Hillel Society, which sponsors various activities for Jewish students under the leadership of a rabbinic seminarian; and organizations for Hindu and Moslem students. A variety of Protestant Christian organizations are available to students, including the Lehigh Christian Fellowship, Navigators, and the Fellowship of Christian Athletes.

The chaplain's office makes information about religious life available to all students in the Fall and can be contacted at any time for information about worship opportunities and religious activities either on campus or in the local Bethlehem community.

Student Organizations

Lehigh offers a wide field of extracurricular activities and student organizations. There is a campus radio station, a twice-weekly student-run newspaper, a dramatic club, musical organizations, and many other opportunities for participation. Course societies promote intellectual interest in various fields of study and develop professional spirit among students.

Interest and hobby groups include art, ballet, band, chess, camera, computer, languages, rugby, sailing, skiing, boxing, judo, model railroading, political clubs, fencing, and waterpolo. These are described in the *Lehigh Handbook*, which is distributed to all students.

Many students also are elected to honorary societies and others join course societies.

Lehigh University Theatre

The department of theatre produces four plays yearly in its mainstage subscription series, presented at Wilbur Drama Workshop. The plays range from the classics to world premieres, and in recent seasons have included *Endgame*, *Rashomon*, *As You Like It*, *On the Verge*, *After the Fall*, *Glengarry Glen Ross*, *The Misanthrope*, and *Candida*.

Auditions are open to all members of the university community. All interested students are welcome to participate on production crews such as set construction, properties, lighting, sound, and wardrobe. Advanced students have opportunities to direct or design, under faculty supervision.

The Lab Theatre in Coppee Hall hosts shows directed and produced by students as class projects or independent work. Recent Lab Theatre productions have included *The Bear*, *Hopscotch*, *The Shawl*, *This Property Is Condemned*, *The Fallen Angel*, *Penguin Blues*, *Terminal Bar*, and *Where Have All the Lightning Bugs Gone?*

Outstanding work in the mainstage or Lab Theatre seasons may be recognized with Williams Prizes and Theatre Department prizes in acting, directing, design, and technical production.

Professional guest artists — directors, playwrights, designers, and actors — regularly visit the Lehigh campus to work on mainstage productions, teach classes, and conduct seminars and workshops for all interested students.

The department also sponsors artists-in-residence, guest lecturers, workshops, and touring performances. Recent guests have included playwright Wendy Wasserstein, translator Edwin Honig, Second Hand Dance Company, and Irondale Ensemble.

In spring 1994, the department will co-sponsor, along with the Office of Cultural Affairs and Touchstone Theatre, "Theatre of Creation," an international festival of movement theatre.

Musical Organizations

The university sponsors both a variety of student musical organizations that give performances on and off campus and a professional concert series, Music at Lehigh, that brings visiting artists to the campus. The choruses, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders.

Christmas Vespers and Spring Vespers are traditional choral performances. The university choir has toured Canada, Puerto Rico, the Virgin Islands, Washington, D.C., California, and throughout Pennsylvania.

The Choral Union, formed in 1985, performs major works with orchestra. It is open to all students, faculty, and staff as well as members of the community.

The Wind Ensemble plays a winter concert and a pops concert on campus during the spring and takes an annual

tour to various locales (Florida, Montreal, New Orleans, Boston, Bermuda, etc.). The Concert Band performs a joint concert with the Wind Ensemble in the winter and a final concert in the spring. The Concert Band is open to students, faculty, and staff as well as members of the community.

The Jazz Ensemble plays concerts on campus, at festivals, and on the joint Wind Ensemble tour in the spring. The Jazz Band performs jointly with the Jazz Ensemble and on the final Concert Band concert.

Performances by the string orchestra and the ensembles traditionally close the semester concert season. The ensembles include groups of string, brass, woodwind, percussion and mixed instruments. Recent additions have been ensembles of Renaissance instruments from the university collection.

The Lehigh University Very Modern Ensemble (LUVME) combines students, faculty, and professional musicians who perform the music of the 20th Century. LUVME also sponsors concerts of music by Lehigh student composers and annually brings a composer of national reputation to campus in order to discuss and play his/her music.

The "97" marching band is widely known for its imaginative and spirited performances on the gridiron and in the stands in support of the Lehigh football team. Pregame and half-time performances are precision drills with a varied repertoire from classical music to traditional fight songs. Nine students serve in executive positions.

The concert series Music at Lehigh presents a variety of concerts and recitals. Among the artists who have appeared are the Orpheus Chamber Orchestra; Calliope: A Renaissance Band and Dawn Upshaw, Met soprano. Inaugurated in 1980, the Ralph Van Arnam Chamber Music Series presents concerts of outstanding chamber music; the series honors the memory of a Lehigh faculty member.

Private instrumental and vocal lessons with instructors approved by the music department are open to all students. The cost of lessons is in addition to tuition expense.

Volunteer Services

A wide variety of volunteer activities are available at Lehigh through living groups, student clubs or organizations or special projects such as Community Interaction Day and Benefit for the Homeless. Typically, well over 1000 students a year participate in volunteer service efforts in the Lehigh Valley area in a range of service programs.

Most of the volunteer work is done in cooperation with local community agencies. Some of the projects include tutorial programs in public and private schools, work in local hospitals, fund raisers for national charities or affiliation with groups such as Habitat for Humanity, Big Brothers/Big Sisters and New Bethany Ministries.

Organizations as well as individuals looking to help their community can consult the Community Service Desk coordinated by the University Chaplain in Johnson Hall. Volunteer opportunities are also posted on Lehigh's campus-wide computer network system.

Guest Speakers

Students have the opportunity to hear a wide variety of notable speakers. The speeches are offered free of charge. Many of the speakers appear under the auspices of the Visiting Lecturers Committee. Committees with access to special funds and academic departments regularly offer presentations by scholars from various disciplines. In addition to delivering a formal address, the speakers are often invited for brief residencies to provide opportunities for more informal interaction with students.

Among those to visit the campus have been attorney F. Lee Bailey, Lee Iacocca, philosopher Derek Parfit, actor Vincent Price, South Africa's Bishop Desmond Tutu, and novelist John Irving. Thomas Armstrong, director of the Whitney Museum, spoke with students during a week-long residency. An Engineering Expo with speakers representing many prominent industries featured Peter Bridenbaugh, vice president of science and technology, Alcoa. From art to engineering, the campus stays in touch with current issues,

trends, and movements through its many and varied speaker series.

Athletic Opportunities

Students can participate in many intercollegiate, recreation, and intramural athletic programs.

Intercollegiate, varsity-level sports include the following. FALL: football, men's and women's cross-country, men's and women's soccer, women's field hockey, and women's volleyball and tennis. WINTER: Men's and women's basketball, wrestling, men's and women's indoor track and swimming. SPRING: Baseball, tennis, golf, men's and women's outdoor track, and lacrosse and women's softball.

Athletic facilities are located in Taylor Gymnasium and Grace Hall and on the Murray H. Goodman campus, which is located two miles south of the main campus. The 500-acre Goodman athletic complex includes the Stabler Athletic and Convocation Center, which seats 6,000 and hosts most of Lehigh's wrestling matches and basketball games. The campus also contains the Philip Rauch Field House, which includes a one-eighth-mile track and indoor tennis and basketball courts. Goodman Stadium, a 16,000 seat stadium for football, soccer and lacrosse was added in 1988. Other facilities on the campus include a championship cross-country course, baseball and softball fields, indoor squash courts, tennis courts, lacrosse and field hockey fields, and an all-weather, nine-lane, outdoor 400-meter track.

Lehigh is affiliated with the National Collegiate Athletic Association (NCAA), the Patriot League and the Eastern College Athletic Conference (ECAC). Lehigh frequently hosts championship events in men's and women's sports.

Intramural Sports

The department of intramural sports and recreation supervises some 30 intramural sports and the recreational physical activities of students. The aim is to insure the health and physical development of students.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, and a spirit of cooperation, and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

On a club-level, there are from 20 to 25 common-interest groups ranging from karate and judo to Frisbee and floor hockey. Several club level teams compete with other colleges on a regular basis (crew, rugby, ice hockey, etc.) Students are encouraged to pursue their special interests.

Also available are instructional classes in aerobics, in addition to such special tournament events as punt-pass-kick, tug-of-war and three-on-three basketball. Also a recreational basketball league is played on Sunday nights. The intramural office provides picnic bags filled with bats, softballs, and other recreational equipment. The facilities in Taylor Gymnasium and Philip Rauch Field House are also available at listed times.

Good Citizenship

The university exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these

goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by the society of which the university is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectancies pertaining to individual and collective behavior. Thus, the university has the obligation to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those that the university regards as essential to its educational objectives and to community living.

Lehigh relies primarily on general principles and statements of expectation for standards of conduct, and assumes that those admitted to the university community are capable of accepting that responsibility. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Student Handbook*. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members.

All members of the university community are subject to municipal, state, and federal laws. The university is not a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens and will direct them to legal counsel when necessary. Off-campus misconduct may be the basis for disciplinary action.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

Policy on Dissent

The university faculty has a policy on dissent that emphasizes the responsibility of all members of the university community. The guidelines adopted broadly set forth the following acceptable forms of dissent on campus:

1. Free inquiry and free expression, including the right to open dissent, are indispensable in achieving the goals of an academic community.

2. Coercive activities employed by individuals or groups either to repress legitimate dissent or to demonstrate dissent are a threat to the openness of the academic community and will be dealt with as an extremely serious matter.

3. Where physical coercion is employed or physical obstruction persists and the university is prevented from resolving the matter through its established disciplinary procedures, legal sanctions will be employed.

This statement provides that orderly and peaceful demonstrations on campus are not forbidden unless they interfere with legitimate university functions. The authority for making the initial judgment in determining the permissible limits of protest rests with the president and counsel of an advisory committee consisting of four faculty members and four students.

Conduct that exceeds permissible limits will be met with university sanctions ranging in severity from admonition to expulsion, or in cases of aggravated or persistent violation of defined rights, with civil arrest and prosecution under an appropriate charge. Prime authority for discipline rests with the faculty and the university committee on discipline.

II.

University Resources



A student enrolled at an institution of the size and tradition of Lehigh can draw upon many resources to enhance the educational experience. These range from classrooms and laboratories with modern equipment to expert faculty members and extensive library collections. Indeed, university's 1,600 acres comprising its three Bethlehem classes are a special resource, providing a beautiful environment for learning. Following are descriptions of various resources related to academic programs.

Collections and Computers

The directness of the printed word, the vision of art, and the power of computers all play important roles in a broad, liberal education. University collections and facilities place a wealth of information at the student's disposal.

Libraries

The Lehigh Library system serves as the information hub of the University, as well as an essential element in the educational process, providing users access to both electronic and traditional resources, including extensive book, journals, microform, software, and media resources. In 1992 the Libraries celebrated the acquisition of its one millionth volume and the 125th anniversary of the Library system, along with continuing transformation from the paper library to an electronic information center.

Using the concept of LibeSpace ("the wide open library"), any user may access not only local databases, such as the online catalog, ASA, but a wide spectrum of remote databases from every residence hall, faculty office, classroom, and laboratory. Included in the array of remote databases are the tables of contents of over 11,000 journals, connections to other university library catalogs via the Internet, access to the holdings of 13,000 libraries throughout the world, as well as several hundred international electronic databases, including full text. All library services are available electronically through the campus-wide network: these include requesting reference assistance; obtaining documents as photocopies or through interlibrary loan; requesting media services; requesting circulation recalls and reserves, etc. A CD-ROM LAN, with a wide range of 52 subject databases, may be accessed through remote login from other public sites on campus.

Facilities and Collections

With the opening in 1985 of the E.W. Fairchild-Martindale Library and Computing Center, adjoining the Mart Science and Engineering Library, the combined information center merged more than 500,000 volumes in the social sciences with a 200,000-volume collection in the natural and physical sciences, mathematics, and all branches of engineering. The new facility, which has a total capacity of 650,000 volumes, also houses government documents and business collections.

The historic Linderman Library, part of which was built in 1877, is dedicated to all branches of the humanities. A

collection of 400,000 volumes encompasses strengths in British colonial history, and American and English literature. The Bayer Galleria of Rare Books, which opened in 1985, embraces the university libraries' Special Collections Division, estimated to include about 24,000 volumes. Included here are the extensive rare-book collections, many of which were donated by the libraries' benefactor, Robert B. Honeyman, as well as university archives, and Congressional papers. Noteworthy among the treasures in the rare book collection are an original edition of John James Audubon's *Birds of America* and three copies of the first edition of Charles Darwin's *Origin of Species*.

The Chrysler Library on the Mountaintop Campus serves as an electronic access point for the convenience of the academic departments located there.

Resources

Library holdings represent a rich resource for the university community. In addition to the collection of 1,000,000 volumes, the libraries receive more than 10,000 periodicals and serials, including a well-developed foreign and domestic newspaper collection. Another important research tool is the government documents collection. A partial government depository since the 19th Century, the libraries hold more than 550,000 federal, Pennsylvania, and United Nations documents, as well as a vast collection of technical reports from governmental agencies.

Nonprint collections of nearly 1,900,000 microforms and 30,000 audiovisual resources enhance the traditional book and journal collections. The David M. Greene music collections includes several thousand tapes and cassettes of classical music. The libraries also have a wide range of reference sources in all fields on compact disk. These CD-ROM databases offer yet another alternative for the retrieval of current literature.

University library resources are augmented by memberships in the Lehigh Valley Association of Independent Colleges; PALINET, Pennsylvania Area Library network; IDS, Interlibrary Delivery Service of Pennsylvania; OCLS, Online Computer Library Center; as well as the International Association of Technological University Libraries.

Services

The university library staff, numbering 74 full-time and part-time employees, serves the needs of faculty and students by providing programs that stimulate the use of the information system as a vibrant intellectual resource. Helpful personal assistance is available from staff in such areas as navigating networks for remote data bases, instruction in research bibliographic methodology, library orientation, current-awareness services, and interlibrary loans.

The advent of the campuswide network and the ease of accessing electronic information has enabled the library to supply all users with electronic services as well as traditional services. Users can order material—including photocopies and interlibrary loans—and submit electronic reference inquiries and obtain media services via the network 24 hours a day. The reference staff has been providing a major

instructional effort for end-user searching of both local and remote data bases.

As a convenience to the university community, the libraries have available microcomputers and workstations; and photocopiers.

As a service to the extended community of alumni and regional corporations, the libraries sponsor a fee-based information service for business, industry, and government. A Friends of the Libraries program has also been in existence since 1981. The Friends programs provide another vehicle for university cultural activities in the forms of lectures, concerts, and exhibits.

The libraries are open 108 hours per week and, during the academic year, are open from 8 a.m. to midnight, Monday through Saturday, and noon to midnight on Sunday.

Media Center

University media services include three service areas. The Fairchild-Martindale Media Center provides opportunities for individual and group listening and viewing of audio and video tapes, cassettes, records, slides and films, in a collection numbering more than 25,000 units. In addition, selected computer software is available for loan or use by the university community. The center includes an electronic classroom; a public access site for individual and small group listening and viewing; and microcomputers for general-purpose use.

Media production services, located in Linderman Library, offers a full spectrum of activities, including video and audio production, photographic services, slide preparation, graphics, and computer-generated graphics. Consulting is also available for preparation and handling of equipment.

Special audiovisual services prepare identification cards, handle the equipment needs for public affairs, and serve selected instructional needs for equipment.

Networking

The university has an InteCom digital PBX system that provides integrated voice and data communications services throughout the campus. InteCom in fact permits voice and data communications to take place *simultaneously* over a single communications line; that is, from on campus, a member of the Lehigh community can make an ordinary (voice) phone call and access a remote computer at the same time. The InterCom PBX enables both on-campus and off-campus computer users to access a wide range of centralized and distributed computing resources, including the Computing Center's centralized Network Servers and Compute Servers, a campus-wide network of distributed RISC workstations, and the University Libraries' Online Catalog.

Each student room in the university's residence halls, fraternities, and sororities is equipped with a telephone and an Asynchronous Data Interface (ADI) for on-campus, local, and long-distance voice and data communications services. These ADIs permit students who own microcomputers to access university network services from the convenience of their own rooms. Students who do not own microcomputers may use any of the more than 440 microcomputers and RISC workstations located at public computing sites across the campus. Each member of the university faculty is equipped with a microcomputer or workstation, an ADI, and a telephone in order to facilitate the academic use of the InteCom voice/data communications system in instruction and research.

Students, faculty, and staff may purchase microcomputers and workstations at the university's Microcomputer Store. Those who are considering acquiring a computer of a type not available from the store should consult a member of the Computing Center staff to insure compatibility with the university's voice/data communications system.

Networking at Lehigh extends beyond the InteCom digital PBX described above and includes: Local Area Networks (LANs), which connect many of the computers located at campus computing sites; a high-speed "backbone" network which currently connects the computing resources of major on-campus research centers

and many academic buildings; access to state-wide PREPnet network; and, access to the Internet, an international network that links national and regional networks from around the world. Note that PREPnet, Lehigh computer users can access the resources of the Pittsburgh Supercomputing Center (PSC), which houses and operates a Cray Y-MPC90 parallel vector-processor (configured with 16 processors) and a Connection Machine CM-2 massively parallel processor (configured with 32,768 processors).

Computing Center

With its distinguished heritage of teaching and research in engineering and science, Lehigh has made extensive use of computers for more than two and a half decades. In response to the need for an independent organization to serve the diverse needs of the academic community, the Lehigh University Computing Center (LUCC) was formed in 1966. Today, LUCC provides computing services to all university departments and research centers, serving the existing needs of students, instructors, researchers, and administrative users while anticipating and preparing for the future requirements of its user community.

The central computing facility, which is located in the E. W. Fairchild-Martindale Library and Computing Center (Building 8-B), houses a network of International Business Machines (IBM) RISC System 6000 (RS/6000) high-performance computers, configured as centralized Network Servers, Compute Servers, and File Servers. A cluster of three high-end IBM RS/6000 computers (called the Network Server Cluster) provides campus communications services such as electronic mail, campus-wide electronic bulletin boards, and access to world-wide electronic news groups such as USENET. A cluster of two high-end IBM RS/6000 computers (called the Compute Server Cluster) provides compute services for compute-intensive applications, including a variety of programming languages, mathematical and statistical software packages, and graphics packages. Two high-end IBM RS/6000 computers (called AFS File Servers) are configured to provide centralized file services, via the AFS file system, to a campus-wide high-speed network of distributed RS/6000 workstations (called the AFS Workstation Cluster). The Network Server Cluster, Compute Server Cluster, and AFS Workstation Cluster are used primarily for instruction and research. In addition, the Computing Center houses, maintains, and operates an IBM 4381 Model 14 mainframe computer and several dedicated IBM RS/6000 computers which are used exclusively for administrative processing.

Centralized high-speed printing services are provided by several laser printers, some of which support the PostScript page description language. Centralized plotting services are provided by two Hewlett-Packard multi-pen, publication-quality plotters. Distributed printing services are provided by a network of PostScript laser printers located at more than a dozen remote workstation sites around the campus. Local printing services are also provided by Hewlett-Packard LaserJet printers at public microcomputing sites.

In addition to the centralized facilities, described above, LUCC maintains 35 public computing sites, computer classrooms, and computer-equipped lecture rooms across the campus. LUCC operates 11 fully-equipped computer classrooms, suitable for "hands-on" computer instruction; each computer classroom has either IBM-compatible PC's, IBM PS/2's, or IBM RS/6000 workstations which are interconnected via a Local Area Network (LAN), and a large-screen projection system which is connected to the instructor's station. For example, LUCC operates and maintains a writing lab for the Department of English and a multimedia lab for the Department of Modern Foreign Languages and Literature; both of these facilities are an integral part of the curriculum. In addition to these computer classrooms, LUCC maintains 8 lecture rooms suitable for computer-based demonstrations; each of these lecture rooms is equipped with a computer connected to either a large-screen projection system or to large display-monitors located throughout the room.

Approximately 320 microcomputers (primarily IBM-compatible PC's and IBM PS/2's running DOS) are

available for use at the public computing sites. Most of the microcomputers at public sites are connected via Local Area Networks (LANs) running Novell NetWare. Software packages available for the microcomputers at public LAN sites include word processing programs such as WordPerfect, WordStar, and EXP; spreadsheet programs such as Quattro Pro and Lotus 1-2-3; database management systems such as dBASE IV and Paradox; mathematical and statistical applications such as Maple, MathCAD, SAS, and STATGRAPHICS; scientific and presentation graphics packages such as GNUPLOT and WordPerfect Presentations; terminal emulation programs such as MS-Kermit; and high-level programming languages such as PASCAL, C, FORTRAN, BASIC, and PROLOG.

In addition to the microcomputers at public sites, LUCC maintains over 120 IBM RS/6000 workstations distributed at public computing sites across the campus. The RS/6000 workstations run an IBM version of the UNIX operating system (called AIX) with an X-Windows/Motif graphical user interface. As mentioned above, the distributed RS/6000 workstations in the AFS Workstation Cluster are connected via the campus backbone network to the centralized AFS File Servers, which enable each user to access all of his or her files from any AFS workstation. Software available for use on the RS/6000 workstations in the AFS Workstation Cluster includes a variety of mathematical, statistical, graphics, and document-preparation packages, such as Maple, BMDP, the NAG FORTRAN Library, GNUPLOT, and TeX/LaTeX, as well as programming languages such as FORTRAN, C, PASCAL, and ADA.

In addition to the RS/6000 workstations at public sites, the Computing Center manages the Computer-Aided Design (CAD) Laboratory for the Department of Mechanical Engineering and Mechanics. The CAD Lab is equipped with both IBM RS/6000 and Hewlett-Packard workstations, and runs industry-standard CAD applications such as Unigraphics II, SDRC Ideas, and ADAMS.

All of the LUCC centralized Network Servers and Compute Servers, as well as the distributed IBM RS/6000 workstations at public sites, can be accessed remotely from on campus via the campus backbone network, or from off campus via dial-up phone lines. In addition, all microcomputers and RS/6000 workstations at public sites can connect to the centralized machines, as well as to each other—either via the InteCom voice/data communications system or via the campus high-speed backbone network. (See the section on *Networking* for details.)

Educational Opportunities

Seminars on various topics pertaining to computing are held or sponsored by LUCC for faculty, staff, and students; many of these seminars provide an opportunity for guided, "hands-on" experience with various computing platforms and software packages in one of LUCC's microcomputer classrooms. Student accounts are available on all LUCC computing systems. Qualified undergraduates and graduate students may further improve their computing knowledge and proficiency by working part-time in one of the following LUCC service groups: User Services, Systems Programming, Operations, or the Microcomputer Store.

LUCC has prepared a description of its computing facilities and services, *A Guide for Users of the Lehigh University Computer Center*; a supplement to this guide, entitled *Lehigh University Computing Center Computing Systems* is also available. This literature can be obtained free of charge by writing to User Services, Fairchild-Martindale Computing Center, 8-B East Packer Avenue, Lehigh University, Bethlehem, Pennsylvania 18015, or by calling (215) 758-3990.

Policies on the Use of Computer Systems and Facilities

The following policy contains the governing philosophy for regulating the use of Lehigh University's computing facilities and resources. Access to the University's computing facilities and resources is a privilege granted solely to Lehigh faculty, staff, and registered students. Exceptions apply to

those individuals outside the University who pay to use computer applications which are unavailable locally and to those individuals outside the University who utilize services that have been made publicly available through Lehigh. All users of the computing facilities must act responsibly and maintain the integrity of these resources. The University reserves the right to limit, restrict or extend computing privileges and access to its resources. Those who do not abide by the policies listed below should expect at least suspension of computer privileges and possible referral to the University Committee on Discipline.

Offenders may also be subject to criminal prosecution under federal or state law, and should expect the Computing Center to pursue such action. As an example, under Pennsylvania law, it is a felony punishable by a fine of up to \$15,000 and imprisonment up to seven years for any person to access, alter or damage any computer system, network, software or database, or any part thereof, with the intent to interrupt the normal functioning of an organization (18 Pa.C.S. 3933(a)(1)). Disclosing a password to a computer system, network, etc., knowingly and without authorization, is a misdemeanor punishable by a fine of up to \$10,000 and imprisonment of up to five years, as is intentional and unauthorized access to a computer, interference with the operation of a computer or network, or alteration of computer software (18 Pa.C.S. 3933(a)(2) and (3)).

The Computing Center should be notified about violations of computer laws and policies, as well as about potential loopholes in the security of its computer systems and networks. The user community is expected to cooperate with the Computing Center in its operation of computer systems and networks as well as in the investigation of misuse or abuse. Should the security of a computer system be threatened, user files may be examined under the direction of the Computing Center Director.

Policies

The Computing Center's policies include, but are not limited to, the list below.

1. You must not use a computer ID that was not assigned to you by LUCC, unless multiple access has been authorized for the ID by LUCC. You may not try in any way to obtain a password for another's computer ID. You may not attempt to disguise the identity of the account or machine you are using.
2. You must not use the Computing Center's network resources to gain or attempt to gain unauthorized access to remote computers.
3. You must not deliberately perform an act which will seriously impact the operation of computers, terminals, peripherals, or networks. This includes, but is not limited to, tampering with components of a local area network (LAN) or the high-speed backbone network, otherwise blocking communication lines, or interfering with the operational readiness of a computer.
4. You must not attempt to modify in any way a program diskette which the Computing Center supplies for any type of use at its sites.
5. You must not run or install on any of the Center's computer systems, or give to another, a program which could result in the eventual damage to a file or computer system and/or the reproduction of itself. This is directed towards, but not limited to, the classes of programs known as computer viruses, Trojan horses, and worms.
6. You must not attempt to circumvent data protection schemes or uncover security loopholes.
7. You must abide by the terms of all software licensing agreements and copyright laws. In particular, you must not make copies of copyrighted software, unless the Computing Center has a site license specifically allowing the copying of that software. Furthermore, you must not copy site-licensed software for distribution to persons other than Lehigh faculty, staff, and students, nor may you copy site-licensed

software for use at locations not covered under the terms of the license agreement.

8. You must not deliberately perform acts which are wasteful of computing resources or which unfairly monopolize resources to the exclusion of others. These acts include, but are not limited to, sending mass mailings or chain letters, creating unnecessary multiple jobs or processes, obtaining unnecessary output, or printing or creating unnecessary network traffic. Printing multiple copies of any documents including resumes, thesis, and dissertations is also prohibited.
9. The following type of information or software cannot be placed on any university-owned computer system:
 - That which infringes upon the rights of another person.
 - That which is abusive, profane, or sexually offensive to the average person.
 - That which consists of information which may injure someone else and/or lead to a lawsuit or criminal charges. Examples of these are: pirated software, destructive software, pornographic materials, or libelous statements.
 - That which consists of any advertisements for commercial enterprises.
10. You must not harass others by sending annoying, threatening, libelous, or sexually, racially, or religiously offensive messages.
11. You must not attempt to monitor another user's data communications, nor may you read, copy, change, or delete another user's files or software, without permission of the owner.
12. You must not use any of the Center's microcomputers, workstations, or networks for other than a Lehigh University course, research project, departmental activity, or personal communications. These resources must not be used for personal or financial gain unless a Personal, External Educational, or Industrial account (which are all billable) is used.
13. You must not play games using any of the Center's computers or networks, unless for instructional purposes as specifically assigned by a professor.
14. Any network traffic exiting the University is subject to the acceptable use policies of the network through which it flows (PREPnet, NSFNET, etc.), as well as to the policies listed here. In general, commercial use of external networks is prohibited. Copies of acceptable use policies for a number of networks are available from the Computing Center.

The above policies supplement the University Code of Conduct, which covers such acts as theft of computer services (including copyrighted computer programs), theft or mutilation of Lehigh property such as equipment, and the unacknowledged or unauthorized appropriation of another's computer program, or the results of that program, in whole or in part, for a computer-related exercise or assignment.

Software developers should refer to the "Procedure on Software Disclosure and Development" regarding title rights; this procedure can be found in Appendix A-10 of the "Lehigh Research Manual". In general, the University has the title rights to software developed under a University account (see Addendum). This may also apply to Personal and External Educational accounts where the computer usage is related to University-funded activities.

Addendum

The categories below define approved uses of accounts on the Computing Center's research and academic computer systems.

University—to be used by Lehigh University faculty, staff and students for course work, course development, research, communication and departmental activities (including community service). Usage in this category is non-billable.

Personal—to be used by Lehigh University faculty or staff members in conjunction with a consulting project or

students for non-course related, personal projects. Usage in this category is billable.

External Educational—to be used by other schools, colleges, tax-exempt organizations and governmental units. Usage in this category is billable.

Industrial—to be used by an external, non-tax exempt organization or by any non-university individual for personal or financial gain. Usage in this category is billable.

Art Galleries; Museum Operation

The Lehigh University Art Galleries maintain and develop the university's permanent art collection, and present temporary exhibitions designed to encourage visual literacy as a part of the university learning experience. More than twenty exhibitions a year in three campus galleries introduce students and the community to current topics in art, architecture, history, science, and technology. The exhibition schedule is supplemented by lectures, films, workshops, and opportunities for research in the permanent collection. Through exhibitions and programs, the art galleries play an important role in the educational mission of the university.

The art galleries occupy exhibition, storage, office and workshop space in several campus locations. The Ralph L. Wilson and Hall galleries are located in the Alumni Memorial Building; Maginnes Hall houses the DuBois Gallery; Girdler Student Gallery, University Center; Siegel Gallery, Iacocca Hall, Mountaintop Campus, and the administrative office and workshop are in Chandler-Ullmann Hall. The Muriel and Philip Berman Sculpture Gardens are located in the courtyard of Mudd, Mart, Whitaker and Sinclair; Saucan Field, Murray H. Goodman Campus and Mountaintop Campus.

Exhibitions

Exhibitions and gallery events are planned to supplement formal classroom study in the visual arts, to create educational opportunities for the entire student body, and to enrich the cultural life of the campus and the community at large. The annual schedule includes the exhibition of works from the permanent collection, the use of borrowed objects, and the rental of traveling exhibitions from major museums and cultural institutions. Experts in various fields serve as guest curators of special project exhibitions. In addition, interdepartmental projects within the university lead to increased involvement by faculty and students. Undergraduates may take advantage of courses in museum studies as well as independent study in the collection.

Collections

Lehigh University's permanent art collection is a work/study collection intended as a resource for students pursuing formal study in the visual arts or museum studies, for the faculty, and for interested members of the community. Each year, several exhibitions are prepared from the collection. Individual works from the collection have recently been loaned to major museums throughout the nation.

The permanent art collection consists of a variety of works by old masters and contemporary artists. Important collection groups include: the Marion B. Grace Collection of European Paintings (Gainsborough, Reynolds, Goya, Hobbema, Hoppner, and others); the Dreyfus Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the Ralph L. Wilson Collection of American Art (paintings by Prendergast, Sloan, Henri, Lawson, Bellows, Davies, Burchfield; prints by Whistler, Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse Collection of Prints (Delacroix, Matisse, Renoir, Kent, Kuniyoshi, Rivera); the Philip and Muriel Berman Collection of Japanese Prints (Hiroshige, Hokusai, Munakata, Utamaro) and the Philip and Muriel Berman Collection of Contemporary Sculpture.

Also, the Fearnside Collection of European Old Master Prints and Drawings; the Baker Collection of Chinese Porcelains; the Langermann Collection of Pre-Columbian Sculpture; the Mr. and Mrs. Franklin H. Williams African Collection (gold weights of the Akam and West African

objects); the Lehigh University Photography Collection (Bravo, Hine, Weston, Porter, Rothstein, Harvan, Rau, Stoumen, Arbus, Bourke-White, Brassai, Fink, Callahan, Edgerton, Cameron, Abbott, Sander, Winogrand); and the Lehigh University Contemporary Prints Collection (Bearden, Rivers, Anusiewicz, Soto, Roth, Chryssa, Ruscha, Tobey, Calder, Kitaj, Marca-Relli, Genoves).

Lehigh University Press

The Lehigh University Press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Philip A. Metzger, Curator of Special Collections, Linderman Library, serves as director of the press, and members of the faculty of the four colleges serve on its editorial board.

Although the press will publish fine scholarship in all disciplines and fields, special emphasis is given to areas with traditional strength at Lehigh: science, technology and society studies; and 18th century studies.

The university press brings Lehigh's name to the attention of the world of scholarship in a new way. Linking the name of the university to a list of fine work by scholars throughout the country helps reinforce the academic environment for faculty, graduate students, and undergraduates. Lehigh's alumni can also maintain intellectual contact with the university through its press.

Twenty-five volumes have been published since the formation of the Press. Volumes for 1991 include: *The Trans-Alaska Pipeline Controversy*, by Peter Coates (this book was the winner of the press's first manuscript competition); *Technique, Discourse, and Consciousness: An Introduction to the Philosophy of Jacques Ellul*, by David Lovekin; *Critical Perspectives on Nonacademic Science and Engineering*, edited by Paul T. Durbin; *America Views China: American Images of China Then and Now*, edited by Jonathan Goldstein, Jerry Israel, and Hilary Conroy. Volumes published in 1992 include: *Science at Harvard University: Historical Perspectives*, edited by Clark A. Elliot and Margaret W. Rossiter; *Francesco Di Giorgio: Checklist and History of Manuscripts and Drawings in Autographs and Copies From Circa 1470 to 1687 and Renewed Copies (1764-1839)*, by Gustina Scaglia; *Strategies of Expertise in Technical Controversies: A Study of Wood Energy Development*, by Frederick Frankena; *Economics and Politics of Turkish Liberalization*, by Mehmet Odekon and Tervik Nas; *Lehigh University: A History of Education in Engineering, Business, and the Human Condition*, by Ross Yates; *Literature and Technology*, by Lance Schacterle and Mark Greenberg; *New Worlds, New Technologies, New Issues*, by Stephen Cutcliffe, Steven Goldman, Manuel Medina, and José Sanmartín; *Lee de Forest and the Fatherhood of Radio*, by James Hijiya; *Social Responsibility in Science, Technology, and Medicine*, by Paul T. Durbin. Volumes published in 1993 include: *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe*, by Anthony S. Travis; *Competitiveness and American Society*, edited by Steven G. Goldman; and *History of the Abderites*, by Christoph Martin Wieland, translated with an introduction and annotations by Max Dufner.

For more information, contact Dr. Philip A. Metzger, Lehigh University Press, 30 Library Drive, Lehigh University, Bethlehem, Pa. 18015.

Resources for Students

Lehigh's administrators firmly believe that the interrelationship between students' classroom and nonclassroom activities can be fostered to become an educational avenue through which students grow, accept responsibility, and gain maturity in ways that will contribute to productive and meaningful lives. Through various services, students are assisted in becoming informed decision makers. They are also encouraged to develop greater self-awareness and self-confidence in their ability to lead the lives they choose.

General counseling of individual students often begins in the residential setting. Staff members in the residence halls include two live-in professionals, nine graduate students who are hall directors, and approximately eighty undergraduate

residence hall counselors, known as Gryphons. All staff members are carefully selected, extensively trained, and are available to assist resident students who may have a variety of concerns.

Students are also encouraged to seek counsel and guidance from professionals in many areas of student life. The Office of the Student Life serves as a central agency to help students who have questions about academic and procedural matters, personal problems, legal problems, and other general concerns, both through its staff and through referral to other student affairs and academic offices.

Students who need assistance with their physical well-being are referred to the university health center.

If a student is uncertain about or needs to know more about his or her own capacities, interests, or personal characteristics, the university counseling service as well as testing services are available without charge. Confidential interviews may be arranged by any student who wishes to review his or her own progress and further evaluate or refine his or her thinking about future goals.

The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A member of the faculty serves as adviser to Hillel Foundation members, who also may obtain spiritual advice from a local rabbi.

The Office of Career Services offers assistance to students in identifying and developing career options that can be initiated at graduation. The office also manages an active on-campus interviewing program for graduating students.

The registrar assists students who have questions involving matters of transferred credits, graduation requirements, and allied topics.

The Office of Financial Aid consults with students who have financial concerns that are affecting their educational plans.

The Learning Center offers free individual tutoring in reading and study skills, mathematics, and writing.

Many members of the teaching faculty are also interested in students and student life. They serve as academic advisers, activity sponsors, group sponsors and advisers, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students that characterize the smaller institution. Services are available for all student concerns, and the student need only turn to his or her nearest residence hall counselor, professor, or the *Lehigh Handbook* to learn where help can be obtained.

Drug and Alcohol Program

The Office of Alcohol and Other Drug Programs is located on the fourth floor of Johnson Hall in room 419. Services are offered free of charge for a wide range of issues revolving around substance use, misuse, abuse and dependency. Two professional staff members (a Prevention/Education Specialist and a Counseling Psychologist) provide services that span prevention, intervention, treatment and aftercare. Lehigh University recognizes that substance abuse and chemical dependency are issues that touch many families and can deeply affect a student's life. Through our educational programs we encourage students to adopt healthy lifestyles and avoid high risk behavior. They are encouraged to seek assistance if they find themselves having problems because of or with their substance use (alcohol and/or drugs), or if they have friends and/or family having problems with substance use.

Prevention services include the implementation of theme weeks (Alcohol & Drug Awareness Week and Wellness Week), educational programs for living groups on a variety of Alcohol & Other Drug (AOD) topics, and the development of a Peer Education Program.

Intervention services include training programs for Residence Life staff, Peer Educator Groups, and other members of the Lehigh community. The purpose of the training is to develop a broad safety net of interveners that can assist a student with AOD problems to get the help they need. Another service is intervention counseling for people

who are concerned about another's AOD use and want to do a 'caring confrontation' with that person. This is often a very successful way of convincing a person with an AOD problem to seek help.

Individual and group therapy sessions are provided by a Counseling Psychologist who has specialized alcohol and drug training. Therapy groups include a group for adult children of alcoholics and a support group for students who are interested in evaluating or changing their level of alcohol and drug involvement. On campus counseling enables many students to successfully enter into recovery (from alcoholism or chemical dependency) or to significantly alter a previously self-destructive lifestyle without having to disrupt their university career. If a student cannot accomplish this on campus, then referrals to in-patient treatment programs can be made. Aftercare services can be provided once the student returns to campus.

Lehigh University has a growing group of recovering students that maintain two Alcoholics Anonymous (A.A.) meetings on campus. There are also a number of A.A. and N.A. meetings in the surrounding community that students can attend. Al-Anon, a recovery program for friends and family of Alcoholics, presently has one meeting per week on campus. This meeting is maintained by a cadre of faculty and staff from Lehigh's community.

Any contact with the staff of the Office of Alcohol and Other Drug Programs is held in the strictest confidence. Contact with the staff members may last from one session to ongoing sessions throughout the school year.

Appointments are easy to make by calling the Office of Alcohol and Other Drug Programs at 758-5359 or by stopping at the office during office hours (8:30 a.m. to 4:45 p.m.), Monday through Friday.

Health Center

The university offers health services to all students at the Health Center in Johnson Hall. During the fall and spring semesters, doctors are available to see patients, 9:00 a.m. to 5:00 p.m. Monday to Friday, and 9:30 a.m. to noon Saturday. A registered nurse is present to see patients after hours with a physician available on call 7:30 a.m. to 8:00 p.m. Monday through Friday, 10:00 a.m. to 8:00 p.m. Saturday and 12 noon to 8:00 p.m. Sunday. During breaks, hours are Monday to Friday 9:00 a.m. to noon and 1:00 p.m. to 4:30 p.m.

The Health Center staff treats a variety of health problems, including infectious illness and injuries. Gynecologic care is available by appointment. Allergy injections can be administered. Some minor surgery is performed at the Health Center. Many laboratory studies can be done at the Health Center; students are referred to local facilities for X-rays. Patients are referred to local medical and surgical specialists when indicated. More seriously ill students are sent to a general hospital.

Prior to arrival to campus, each new or transfer student must submit to the Health Center a record of physical examination, a completed health history form, and updated immunization record.

Following enrollment, additional examinations are provided by the Health Center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The Health Center does not provide examinations for military, insurance or employment purposes.

There is no charge for most of the care provided to students, whether inpatient or outpatient. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student Health Center, and medications not carried by the Health Center and for which prescriptions need to be given.

A relatively low-cost university-sponsored insurance plan is available. Expenses covered include costs for several services that are not available at the Health Center, such as X-rays, certain laboratory studies, consultant fees, and medications not stocked by the Center. Hospital expenses are also covered. Students are urged to check with their parents regarding existing insurance coverage and to consider purchasing the university-sponsored plan if they are not adequately covered.

A health service brochure is distributed to all entering freshmen and is available through the Health Center to all other students. This brochure describes in more detail the policies and program of health service.

Counseling Service

The Counseling Service, located on the fourth floor of Johnson Hall, offers students the opportunity for consultation with trained counselors and psychologists regarding a wide variety of personal and academic concerns. Staff psychologists are also available to present lectures, workshops, or seminars on psychologically related topics. The service is dedicated to the belief that college years can be productive, rewarding, and satisfying ones during which students can grow in meaningful ways. All of the services provided are *confidential* and *free of charge*. To make an appointment call 758-3880, Monday through Friday. For after-hours emergencies, the on-call psychologist can be reached through campus police at 758-4200.

Counseling/Psychotherapy may involve discussion and exploration related to *any* concerns, feelings or problems that students may have, ranging from those that arise during the course of normal development to more serious emotional problems. Most work will take place during short-term individual or longer group psychotherapy.

When a student consults with a therapist, the initial step of clarifying the concern is often helpful and may be the only work necessary to begin a resolution of the problem. Psychological testing, along with additional individual or group sessions to explore the difficulty in greater depth or to provide ongoing support, may follow.

The most frequent types of concerns which students bring to counseling are:

Anxiety/Stress—When students are nervous, worried or experiencing attacks of acute anxiety their satisfaction and performance declines. Such feelings of stress may interfere with schoolwork, relationships, or athletic performance. Clarifying the source of the stress can help and sometimes there are different techniques that a counselor can offer to help students begin to feel and function better.

Depression/Loss of Motivation/Low Self Esteem—Each of these can effect how satisfied and productive one feels. They may be interconnected or related to other difficulties. Psychotherapy can be helpful in understanding the reason such feelings have become troubling, and can help the individual move toward some satisfactory personal resolution.

Behavior Problems—Problems of behavior are diverse and range from eating disorders, to loss of temper control, to chronic procrastination. The cause and treatment of each problem may be different but such problems have one thing in common, the loss of control over an important behavior. Counseling may involve a thorough analysis of the problem and the use of different techniques to aid in regaining behavior control.

Interpersonal Problems—These may involve problems getting along with a roommate, girlfriend/boyfriend, professor or family member. Often the break-up of a relationship, a divorce in the family, or the pressure of long-standing interpersonal conflicts can contribute to depression, anxiety and work problems. Work in a therapy group may help clarify the problem and the effect it may be having on other areas of functioning. Strategies can be identified to improve the situation and to cope better with the problem as it exists.

Existential Concerns—Not infrequently, students find themselves struggling with those difficult questions of who they are, what their lives are about, and how they can best live with integrity. Addressing some of these concerns in psychotherapy may allow greater freedom and involvement in the academic, personal, and social environment.

Cultural Adjustment—University students come from a diversity of backgrounds varying by race, country, previous college enrollment, gender, sexual identity, rural or urban experience, economic background, religion, and political views to name just a few. Counseling is sometimes helpful during periods of adjustment to multicultural university

diversity, with groups providing an excellent opportunity for broadening personal and interpersonal experiences.

The Learning Center

Success at Lehigh depends in part on mastery of a number of advanced academic skills. Such skills are needed to study effectively (prepare assignments, take notes, outline, listen, recall information), to take examinations, to write well, to understand advanced mathematical concepts, and to keep up with a great deal of critical and comprehensive reading.

At Lehigh, a campus noted for its highly-motivated student body and strenuous academic program, 15 percent of undergraduates, including a third of full-time freshmen, use the tutorial services of The Learning Center. Established in 1977, it provides a schedule of workshops, review sessions, and most importantly, individual tutorials in study skills, mathematics, reading and writing. Through a program of faculty and student referrals, along with periodic notices to the student body, the center helps students to improve specific communication and mathematical skills, to maintain acceptable performance levels, and to raise their academic standing. Individualized assistance is emphasized.

The Learning Center provides university students with a continuing opportunity for academic improvement through personalized instruction by professors and graduate teaching assistants. The center is located in Drown Hall.

The Microcomputer Store

Lehigh's Microcomputer Store offers microcomputers, printers, software and accessories for Lehigh students, faculty and staff at reduced educational prices. The store is located at 524 Brodhead Ave. and is open weekdays from 9:00 a.m. to 5:00 p.m. Information regarding prices, special offers and other related details can be obtained through the campus network or by calling (215) 758-4606. Mastercard and Visa are accepted.

Career Services

One function of a college education is to foster the growth and development of the student in preparation for a meaningful and satisfying life after college. Because developing one's career potential is an integral part of this process, Lehigh provides career planning and placement services for its students.

Career planning can best be described as an educational process through which students (1) identify and develop their abilities, aptitudes, and interests; (2) learn the relationship between their capabilities and interests, their university experiences, and professional opportunities outside the university; and (3) prepare for those opportunities.

Placement is the process of researching specific organizations that provide the types of work desired, interviewing for specific jobs through which career or professional interests can be satisfied, and then selecting from the options available the one that best meets students' needs. This part of the process also requires students to develop skills in such areas as writing effective resumes and cover letters, interviewing techniques, and individual job-search strategies to enhance productive interactions with employers.

The goals of this integrated career planning and placement process are for Lehigh students to think of themselves as educated people with skills and abilities that have value to employers, and to think in terms of functional responsibilities rather than merely linking their major subjects to jobs, to acquire and develop the skills necessary to become self-reliant and informed decision-makers, to prepare for a competitive job market, and to develop their potential of becoming self-reliant managers of their own careers.

The Office of Career Services offers the following resources and services to help students prepare for professional opportunities after graduation:

Career resources. Among the resources available in the

Career Library are books and articles on career planning, current information on career opportunities, occupational information, graduate school resources, job-search directories, a library of employer literature for approximately 600 companies, and a video-tape library covering a wide range of career-related subjects, job listings for part-time, summer, internship, entry-level and experienced opportunities, "user-friendly" national employment databases, an electronic bulletin board with postings and Federal Government information, and a directory of alumni contacts who have volunteered to assist students with their job-search strategies.

Pre-professional advising. The pre-professional advisor, along with a faculty advisory committee, provides information and guidance to candidates pursuing careers in medicine, dentistry, and other health professions, including individualized advising, special programs on health-related topics and field trips. In addition, information and assistance is provided for students interested in law school and legal careers.

Career programs and workshops. The staff conducts a variety of seminars and presentations in collaboration with academic departments, professional societies, living groups, and other interested campus organizations. Career programs like the Graduate School Fair and the Career Fair and many others are offered throughout the year. Workshops on resume writing, interviewing techniques, and job-search strategies are also offered.

Summer and part-time jobs. Summer and part-time job listings and internship opportunities are available through Career Services for all students interested in gaining short-term, career-related experience. This is part of a student employment program designed to offer "hands-on" career experience and financial assistance.

Individual consultation. Students may meet with members of the staff to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests.

Placement Manual. This manual helps students learn how to use the on-campus interviewing system, prepare for interviews and plant/office visits, write resumes and letters, and develop individual strategies.

On-campus interviewing. Staff members work with approximately 500 business, industrial, and government representatives who interview on campus each year. Seniors and graduate students typically take a total of about 6,000 interviews.

The office, located in Christmas-Saucon Hall, is open throughout the year.

Challenge For Success Program

The Challenge For Success Program (CFS) is a comprehensive supportive services program designed to enhance the recruitment and retention of the minority student community. Recruitment, retention, and relationships with industry are the primary components of the program.

The CFS program director works closely with the office of admission in the area of recruitment. Retention is enhanced by a six-week summer pre-freshman program, a peer counseling program, counseling for social and academic adjustment, a comprehensive tutorial service, and monitoring of academic progress.

The Lehigh University Black and Latino Alumni Council also assists in the retention effort. The CFS Program is partially funded through gifts by corporate friends.

Honor Society for International Scholars

Phi Beta Delta, the International Honorary Society, has the Beta Pi chapter at Lehigh. The purpose of the society is to honor those involved in high academic achievement and service in the international dimension, and to foster international exchange on campus. The honorary has three categories of members: international students who have

demonstrated high scholastic achievement at Lehigh; U.S. students who have demonstrated high scholastic achievement in the pursuit of international academic studies including study abroad; distinguished faculty and staff with international endeavors.

International Multimedia Resource Center

Within the IMRC located in Maginnes Hall are a state-of-the-art multimedia computer lab (Maginnes 470) dedicated primarily to foreign language multimedia applications and the World View Room (Maginnes 490) in which is shown a regular daily schedule of foreign language news and feature programming received via international satellite TV networks. The multimedia lab features a network of IBM PS/2 Model 80 computers with laserdisk players, VCRs, and CD-ROMs designed for use with multimedia software. The World View Room features a comfortable lounge with a large screen rear-projection TV, an assortment of foreign newspapers, journals and magazines; shortwave radio, a variety of visitors—everything to inspire a good international educational and cultural atmosphere. For further information, contact Victor G. Zabolotnyi, Director, IMRC, Maginnes Hall 535, tel. 758-6067/6134, or the Department of Modern Foreign Languages, Maginnes 516, tel. 758-3090.

English as a Second Language

The English as a Second Language Program (ESL) offers academic year (Fall and Spring) courses and programs for enrolled undergraduate and graduate students and their families. In addition, academic support is provided for ESL students in free individual and small group tutoring and conversation groups, an academic resource center with books, tapes, and computer programs, and in low-cost language enrichment courses.

Courses. After placement testing undergraduates accepted by the ESL Program and the English Department may take English 3 and English 5 (English as a Second Language) in substitution for English 1 and 2.

Both undergraduate and graduate students may select from a variety of ESL credit courses in speaking, accent reduction, reading, and writing offered throughout the year. Contact the ESL Program for an updated list.

The TLC (The Lehigh Community) Program offers non-credit enrichment ESL courses three times yearly at a low cost to enrolled students and members of their families and to members of the surrounding community. Call for a course list.

Intensive summer program. The STEP/UP Program provides an intensive academic ESL experience for both enrolled Lehigh students and for other students preparing to enter an American university in the near future. STEP/UP is a pre-university program to enhance skills in academic reading and writing, formal academic language, and an orientation to American culture and student survival skills. Students entering STEP/UP should be at a high intermediate or advanced English level.

For further information, contact Judith Rance-Roney, ESL Director, 33 Coppee Drive, Bethlehem, PA 18015; tel. (215) 758-6099.

Office of International Students and Scholars (OISS)

The OISS is a campus-wide resource for relevant international issues. It serves the unique needs of foreign nationals who are students, scholars, faculty and staff members, plus their families. More than 900 internationals from over 65 countries currently enrich the campus. The office also serves the Lehigh community with information and resources on a variety of international issues. It is actively engaged in helping to foster international exchange through students, alumni, faculty and research.

The office advises on immigration, visa, and personal matters. It is a liaison with other offices and departments on campus, and with national and international agencies. It maintains an electronic bulletin board, INTERNAT, for international information of all kinds, and an electronic mailing list consisting of all internationals on campus. It publishes a *Handbook for International Students and Scholars*. In conjunction with the Alumni Office, it maintains connections with international alumni.

The office initiates a variety of cross-cultural programs, including extensive orientations, International Advisory Committee, Student Mentor program, International Partners program, spouse conversation group, valley-wide workshops and seminars on immigration matters and taxes, an annual bazaar, trips. The OISS sponsors the Cultural Exchange Committee, the International Club, and Phi Beta Delta.

The office is located in Room 344, Whitaker 5. Tel. 215/758-4859. FAX 215/758-4244.

Other Services to International Students

HEALTH CENTER for both physical and personal needs. The Counseling Center has special services for international students.

CAREER SERVICES with special advising and workshops for international students.

CISH, Council for International Hospitality and Service, a community friend family organization.

RELIGIOUS SERVICES for all the world's major religions. There are Christian, Jewish and Muslim services on campus and in the community, and Hindu and Buddhist temples in the area.

NATIONAL CLUBS with home country members from all the regions in the world. They form an important part of the cross-cultural dimension of the campus, providing social events, films, and international dialogue.

STUDENT HOST PROGRAM, for both undergraduate and graduate students. Current students on campus have volunteered to host and mentor incoming international students.

LEARNING CENTER which provides tutorials in math and writing.

LEHIGH GLOBAL NETWORK, which provides outreach to Lehigh's international alumni, either here in the U.S. or in their home country.

III.



Undergraduate Studies

Graduation Requirements

Students are expected to maintain regular progress toward the baccalaureate degree by carrying the "normal" course load—between twelve and eighteen credit hours each semester. They may, however, wish to accelerate the pace toward graduation by using advanced placement credits, summer session study, course overloads during the regular semesters, and receiving credit for courses through examination.

Students in good academic standing earn their degrees by meeting the requirements of their specific degree curriculum as well as general university requirements. Students should confer with their advisers on matters related to curriculum.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science or aerospace studies credit hours are in addition to the credit hours specified in the curricula. A maximum of six credit hours of advanced military science and aerospace studies courses may be applied toward the baccalaureate degree.

Undergraduate Residency Requirement

To be eligible to receive a Lehigh baccalaureate degree, the candidate must have completed either a minimum of ninety credit hours in residence, or all of the last thirty credit hours at the University or in residency programs.

Five-Year, Two-Bachelor-Degree Programs

The university's five-year, two-degree programs enable a student to receive two bachelor degrees upon completion of five years of study.

The civil engineering and geological sciences program that affords two bachelor degrees, and the electrical engineering and engineering physics two-degree program are examples of programs in the College of Engineering and Applied Science.

Some five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs in Section V. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five years if the decision is made before the third year.

Second degree candidates—A student entering Lehigh to obtain a second bachelor's degree, or those Lehigh students who wish to declare a second major in another college, or both a B.A. and a B.S. degree within the College of Arts and Science must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. All of the thirty

additional credit hours must be taken at Lehigh or in Lehigh residency programs. All special second degree programs must be approved by the dean of the college in which the degree is to be offered and the Standing of Students Committee.

Advisement

Every undergraduate is assigned a faculty adviser. Until the major is declared, assistance is also available through the dean's office of the college in which the student is enrolled. When the major has been chosen, a faculty member from the major department will act as the academic adviser.

This adviser is one of the most valuable resources in the educational process, not only to assist in making academic selections to match the student's particular background, interests, and future objectives, but also to identify program options, to work out an academic pace, and to develop career planning strategies. The adviser will help to identify other resources and support systems available at the university, such as The Learning Center, the counseling service, and the office of career services.

Guide to Academic Rules and Regulations

The university, like the rest of society, has adopted over the years numerous rules and regulations. Some of the principal rules and regulations are given here so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

This section concerns academic regulations. Additional regulations can be found in the *Lehigh Handbook*, and there is a comprehensive statement of all policy in the publication *Rules and Procedures of the Faculty*. All students are given a *Handbook* at the beginning of the fall semester; *Rules and Procedures* is available in the university libraries and in departmental and administrative offices.

Eligibility for Degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 2.00.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for meeting academic requirements. Each student is responsible for his or her progress toward meeting specific requirements for graduation. Academic advisers and department chairpersons are available to assist the student.

It is strongly recommended that the students specifically consult with his or her adviser prior to the senior year to ascertain eligibility for the degree for which he or she desires to qualify and to determine that all program and hours requirements are met.

The Registrar's office will provide, at the student's request, a printout of a degree audit noting all program deficiencies. All students are requested to go through this process before registering for their senior year.

Final date for completion of requirements. For graduation, all requirements, scholastic and financial, must have been satisfied prior to the date stated in the university calendar.

Application for Degree

Candidates for graduation on University Day in May or June must file with the registrar on or before March 2 a written notice of candidacy for the degree; candidates for graduation in January file a notice of candidacy on or before December 1; candidates for graduation on Founder's Day, the second Sunday in October, file a notice of candidacy on or before September 1.

Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee is assessed.

Graduating Thesis

The original of the undergraduate thesis, when required, is accompanied by drawings and diagrams whenever the subject need such illustration. The original is kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

Undergraduate Credit and Grades

A semester hour of college work consists of one hour a week of lectures or classwork, or two or three hours of laboratory work per week (or laboratory work combined with classwork) for one semester. The normal assumption is that the student will be expected to do at least two hours of study in preparation for each hour of classwork. *The term "semester hour" is used interchangeably with "credit hours."*

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester, or fifth day of a summer session.

Definitions of grades. Course grades are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, P, F, N, and X. The meaning of each grade is as follows: A, excellent; B+, B, and B-, good; C+ and C, competent; C-, continuation competency (the student has achieved the level of proficiency needed for the course to satisfy prerequisite requirements); D+, D, and D-, passing, but in the estimate of the teacher, the student may not be adequately prepared to take any subsequent course that has the particular course as a prerequisite. A student must obtain his or her adviser's permission to use courses in which a grade of D+, D, or D- is received to meet prerequisite requirements; P, pass-fail grading with a grade equivalent to D- or higher; F, failing; N, incomplete; X, absent from the final examination; XN, absent from the final examination and incomplete.

Other symbols used for courses on student records are: Cr, credit allowed; W, withdrawn; WP, withdrawn with permission and with passing performance at the time of withdrawal; WF, withdrawn beyond the deadline and/or with failing performance.

Grades in the range of A through D-, P, and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, XN, W, WP, and WF cannot be credited toward the degree. Grades of W and WP do not count as hours attempted.

Courses in which grades of F, W, WF, N, X, or XN are recorded do not meet prerequisite requirements.

The grade N (grade) may be used to indicate that one or

more course requirements (e.g., course report) have not been completed. It is the obligation of the student to explain to the satisfaction of the instructor that there are extenuating circumstances (e.g., illness or emergency) that justify the use of the N grade. If the instructor feels the N grade is justified, he or she assigns a grade of N supplemented by a parenthetical letter grade, (e.g., N(C)). In such cases, the instructor calculates the parenthetical grade by assigning an F (or zero score) for any incomplete work unless he or she has informed the class in writing at the beginning of the course of a substitute method for determining the parenthetical grade.

In each case in which an N grade is given, the course instructor shall provide written notification to the department chairperson stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade and the grade for the work already completed.

A student who incurs an N grade in any course is required to complete the work for the course by the fifth day of instruction in the next regular semester. The N grade will be converted into the parenthetical grade after the tenth day of instruction in the next regular semester following receipt of the N grade unless the instructor has previously changed the grade using the removal-of-incomplete procedure. The parenthetical grade will be dropped from the transcript after the assignment of the course grade.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

N grades do not count as hours attempted and are not used in computations of cumulative averages.

The grade X (grade) is used to indicate absence from the final examination when all other course requirements have been met. The grade in parenthesis is determined by including in the grade calculation an F (or zero score) for the missing final exam. The X grade may be removed by a make-up examination if the absence was for good cause (e.g., illness or other emergency). To be eligible for the make-up exam, the student must file a petition and the petition must be approved by the committee on standing of students. If the student fails to petition, or if the petition is not granted, or if the student fails to appear for the scheduled make-up examination, then the X grade will be converted into the parenthetical grade after the first scheduled make-up examination following the receipt of the X grade. If the petition is granted and the final examination is taken, the X grade will be changed by the instructor using the make-up examination procedures and the parenthetical grade will be dropped from the transcript.

Where valid reasons exist for not taking the make-up examination at the scheduled time, the student may petition for a later examination with a fee.

The notation of NR (not reported) is temporarily placed in a student record when due to circumstances, no grade was reported by the instructor by the established deadline.

The grade XN (grade) is used to indicate both absence from the final examination and incomplete of one or more course requirements. The instructor calculates the parenthetical grade using an F (or zero score) for the final examination and either an F (or zero score) or the substitute method of calculation as described above for the incomplete work.

The XN grade may be removed by the procedures presented in the previous paragraph for removing the X grade. If this results in an N grade because the course work is still incomplete, the provisions Incomplete (N grade) above shall apply, except that in no case shall the deadline for completion of the work be later than the last day of classes in the first full semester in residence (except summer) following receipt of the XN grade.

X and XN grades do not count as hours attempted and are not used in computations of cumulative averages.

Where failure to complete coursework prevents the student from taking the make-up examination at the scheduled time, the student may petition the committee on standing of students for a later examination.

An XN grade that is still outstanding after the tenth day of instruction in the next academic-year semester following

receipt of the XN grade will be converted into the parenthetical grade. The parenthetical grade will be dropped from the transcript.

A withdrawal from a course within the first ten days of instruction is not recorded on the student's record.

A student wishing to withdraw from a course after the tenth day, but not after the ninth week of instruction, must proceed as follows: The student indicates intention in writing to withdraw from the course, giving the course number, title, and credit hours; the student presents the drop and add form to the adviser and the course instructor. Each signs the form to indicate that he or she has seen it and discussed it with the student, and notes appropriate recommendations; the signed form is delivered to the registrar. He or she records a W for the course on the student's transcript.

A student who withdraws from a course but not the university after the ninth week of instruction will automatically receive a WF for the course.

A student who officially withdraws from the university after classes begin through the ninth week of instruction receives grades of W in the courses for which he or she is registered. Thereafter, each course instructor assigns a grade of WP or WF.

A student who reduces his or her course load below the minimum required for standing as a full-time student, but does not withdraw from the university, becomes a part-time student for the rest of that semester. Some areas affected by part-time status are financial aid, athletic eligibility, veterans affairs, selective service, immigration status, insurance and loan deferment.

Official reports of grades are issued to advisers and students by the registrar as soon as possible following the deadline for reporting of grades. Instructors may develop their own policies for release of unofficial reports of academic progress to individual students, or to their advisers, deans, or financial aid officers, on a need-to-know basis, including early release of unofficial final course grades. Any such policies must respect the rights of students to privacy.

A report of grades is sent to each student's home at the end of every semester.

Repeating of courses. If a course in which a "D+" or lower grade was received is repeated, the final grade received upon repetition of the course is counted in the cumulative average. The original grade and credit hours received will be dropped from the cumulative average. Courses assigned a grade of "C-" or better may not be repeated. However, a student who fails a repeated course after receiving a passing grade the first time will have the original grade deleted from his or her average, but will retain credit for the course toward graduation.

A grade of D+ or lower that was originally received in a course may not be changed by repeating the course under the pass-fail option.

For deletion of a grade from the cumulative average after repeating a course, a student must (a) file the deletion form with the Registrar's Office; and (b) repeat the identical course with a final grade at Lehigh.

Pass-Fail Systems for Undergraduates

Student Option System. The pass-fail grading option is intended to encourage students to take challenging courses outside the major field that otherwise might be avoided for fear of lowering grade-point averages. Students should avoid wasting this option on unsuitable courses, such as introductory courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

A student may register for no more than two courses pass-fail in any one semester. He or she may take a maximum of six courses pass-fail per undergraduate career if the student is on a four-year program, or a maximum of eight courses per undergraduate career with a five-year, two-degree program. If a student changes a course after the first ten days of instruction from pass-fail grading to regular grading, as provided below, that course shall still count

toward the maximum number of courses taken pass-fail during the student's undergraduate career.

Each college faculty shall decide under what conditions and which courses or categories of courses throughout the university may be taken for pass-fail credit by students registered in that college, except for courses designated specifically for pass-fail grading. Each college shall keep the educational policy committee advised of changes in its rules.

A student designates the course(s) to be taken pass-fail normally at preregistration but not later than the fifth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail to regular grading, or vice-versa, without penalty. The courses designated for pass-fail grading by the student require the written acknowledgment of the academic adviser.

Since the instructor giving the course is not officially notified which students are taking the course pass-fail, a regular letter grade is reported to the Registrar for the course pass-fail students. The Registrar then records "P" for reported letter grades from A through D-, and "F" for a reported letter grade of F.

Under this system, the student surrenders his or her equity to letter grades of A through D-, except as specified below. A grade of P applies to the student's graduation requirements but is not used in the computation of the cumulative average; whereas an F grade is included in the cumulative grade point average.

If a student changes his or her program such that a course previously taken for pass-fail grading is not allowed for pass-fail grading in the new program, the student must submit a petition to the committee on standing of students requesting acceptance by the new program of the pass-fail grading for that course, or substitution of the original letter grade submitted by the instructor for the pass-fail grade, or the substitution of another course for the course taken pass-fail. The recommendation of the adviser must accompany the petition.

Courses at the 400 level are excluded from pass-fail grading.

Course Auditing

A student who is in good academic standing and has not failed any courses in the previous term may be admitted as an auditor in not more than one course, which shall be outside the curriculum requirements. Application for such admission is by petition approved by the departmental chairperson and the chairperson of the department concerned. In no case shall a student who has attended a course as an auditor be given an anticipatory examination for credit or register for the same course in the future. A student completing a course in this manner will have the course and the notation AU indicated on the permanent record. A student rostered on an audit basis may be withdrawn from the course with a grade of W for poor attendance.

Review-Consultation-Study Period

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations.

It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during this period.

No quiz or exam may be given during the last five class days before final examination period begins.

Scholastic Averages and Probation

Scholastic requirements for undergraduate students are expressed in terms of the cumulative grade point average (GPA)—the weighted average of all grades received in residence or at institutions specifically approved for grade transfer. The cumulative GPA is computed at the end of

each semester and the second summer session. Following are the cumulative GPA requirements for good standing:

freshmen 1st semester 0 to 5 credits earned	1.60
freshmen 2nd semester 6 to 21	1.70
sophomores 22 to 51	1.80
juniors and seniors more than 51	2.00

Students who do not meet the above requirements will be placed on scholastic probation. Students who, regardless of their cumulative average, have failed more than eight hours of course work in any semester are also placed on scholastic probation.

While there is no specific credit hour requirement for good standing, certain categories of students (e.g., those on financial aid and those playing intercollegiate athletics) will be expected to maintain whatever hours are required for eligibility.

Removal from probation. Students are removed from probation at such time as they meet the standard listed above, effective at the end of any semester or the second summer session.

Dropped for poor scholarship. A student who makes a 2.2 GPA or better in the probationary semester but fails to meet the standards stipulated is continued on probation for another semester. A student who makes less than a 2.2 GPA in the probationary semester and fails to meet the standards stipulated above, is dropped for poor scholarship.

If a student goes on scholastic probation for a second (although not necessarily consecutive term,) a review by the committee on standing of students will determine whether the student will continue on scholastic probation or be dropped for poor scholarship.

Graduation Honors

Degrees *with honors* are awarded by vote of the university faculty to those students who have attained an average of not less than 3.25 in a minimum of ninety credit hours in residence at Lehigh University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

Degrees *with high honors* are awarded by vote of the university faculty to those students who have attained an average of not less than 3.50 in a minimum of ninety credit hours in residence at Lehigh University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

Degrees *with highest honors* are awarded by vote of the university faculty to those students who have attained an average of not less than 3.75 in a minimum of ninety credit hours in residence at Lehigh University or in programs approved by the Faculty to have grades and credit accepted toward the undergraduate degree.

For the purposes of graduation honors calculations, courses taken more than once at Lehigh will only have the most recent grade used in the calculation. Courses taken under the cross registration policy of the IVAIC, and those courses taken in faculty approved study abroad programs through the Lehigh Study Abroad program will be used.

Students who spend part of their career at another institution, or are transfer admits to degree programs and have fewer than ninety hours of in residency courses, may qualify for graduation honors under the following conditions:

The student must have at least sixty credit hours of regularly graded (not pass/fail) courses that meet the residency requirement. The graduation honors category is determined by the lower of the two averages computed as follows: (1) the average of grades received at Lehigh; (2) the average of all grades received at Lehigh and grades for courses taken elsewhere for a regular grade and that are appropriate to be considered for transfer to Lehigh, or in provisionally approved study abroad programs.

Department Honors

Each department offers honors work adapted to its curriculum for students who wish to demonstrate unusual academic ability and interest in exploring a chosen field through independent study and research. The precise nature of the program for each student is determined by the academic major department, but may include: unscheduled work or independent study; participation in graduate (400-level) courses; and an honors thesis or project.

Qualified candidates should inform their academic advisers by the end of the junior year of their intention to work for departmental honors. The adviser will give the college and the registrar names of seniors working for departmental honors in particular majors. Names of those students attaining departmental honors are published in the commencement program.

Undergraduates in the College of Arts and Science may apply for acceptance into the College Scholar Program, which offers unique opportunities for those qualified to develop their critical faculties and intellectual interests.

Honor Societies

There are at least eighteen honor and course societies. The three best-known are:

Phi Beta Kappa. The desired profile for this Arts and Science honor society consists of:

- A minimum cumulative GPA of 3.5
- In addition to a student's major, which might encompass one of the distribution requirements noted below, a student should present a minimum of—
- Two natural science courses, with at least one lab as part of that instruction
- Two social science courses
- Two humanities courses, especially reading/critique of literature beyond basic freshman English
- Inclusion of the study of calculus, or advanced mathematics
- Study of foreign language roughly equivalent to 2nd-year college level
- No academic violations sufficient to warrant suspension

While satisfaction of this profile does not guarantee election, it ensures being considered by the council.

Beta Gamma Sigma. Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

Tau Beta Pi. Tau Beta Pi recognizes high achievement in all engineering curricula. The national Tau Beta Pi was founded at Lehigh in 1885. A bronze marker in front of Williams Hall commemorates this event.

Among course societies are the following: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Epsilon, Economics; Omicron Delta Kappa, leadership; Order of the Omega leadership in Greek activities; Phi Alpha Theta, history; Phi Beta Delta, international; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

College of Arts and Science

James D. Gunton, *dean*; Julie A. Williams, *associate dean*; Howard R. Whitcomb, *associate dean*

The College of Arts and Science offers several curricular options:

- A four-year curriculum in arts and science, leading to the degree of bachelor of arts; or bachelor of science in designated fields; and
- A five-year curriculum in arts-engineering leading to a bachelor's degree from the College of Arts and Science and a bachelor of science degree in the student's field from the College of Engineering and Applied Science.
- Double degree programs within the college and in conjunction with the other two undergraduate colleges are possible.

Specific requirements for many of the degree programs described in this section may be found in Section V.

Major Programs in the College

The college offers the following major programs:

Bachelor of Arts Degree

Humanities: architecture; art; classics—classics and classical civilization; East Asian Studies; English; modern foreign languages—French, German and Spanish; music; philosophy; religion studies; theatre.

Social Sciences: American studies; anthropology; cognitive science; economics; government; history; international careers; international relations; journalism and communication; journalism/science writing; psychology; science, technology and society studies; social relations (includes anthropology, social psychology, and sociology); sociology; sociology/social psychology; and urban studies.

Mathematics and Natural Science: biology; chemistry; computer science; environmental science; geology; mathematics; natural science; physics; premedical science; premedical science (these last two only for MCP students).

Bachelor of Science Degree

Behavioral neuroscience; biochemistry; biology; chemistry; computer science; environmental science; geological science; geophysics; mathematics; molecular biology; physics; statistics.

Major Field of Concentration

By the end of the sophomore year, each student in the curriculum of arts and science selects some sequence of studies as a major field of concentration. A major consists of at least fifteen hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is 30.

The major field of concentration is designed to enable a student to master an area of knowledge so far as that is possible during the undergraduate years. In all fields, certain courses are prescribed, but merely passing courses will not satisfy the major requirements. A student must achieve a minimum 2.0 average in major courses.

Standard major sequences. The student may choose one of the standard major sequences. When a student selects one of these standard majors, a faculty member from the department or program offering the major becomes a student's major adviser and makes out the student's major program. The final responsibility for meeting both major and nonmajor requirements, however, rests with the student.

Special interdisciplinary majors. In addition to the standard major programs, specially structured interdisciplinary major sequences are possible.

For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in government and economics, or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, work out an interdisciplinary major program to include not less than thirty hours of related course work, of which at least fifteen hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

Multiple majors. Some students choose to fulfill the

requirements of more than one major sequence. A student initiates this by having separate major programs made out by different major advisers.

Because successful completion of only one major program is required for a baccalaureate degree, a student with more than one program is asked to designate one as the primary major for administrative purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Students who wish to pursue a second degree in another college or both a B.A. and B.S. degree within the college must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. Both sets of major and distribution requirements must be met.

Junior-Year Writing Certification

The faculty of the College of Arts and Science is committed to the concept that writing is a valuable tool for learning and views the ability to write well as a valuable professional skill. Students are encouraged to take courses that require writing throughout their years in the college.

Each student in the college must complete at least one "writing-intensive" course and receive writing certification from the instructor. Students normally take this course during the junior year. Students must follow the guidelines for this requirement set up by their major departments. Some departments specify that the "writing-intensive" course must be in the major field; some departments require "writing-intensive" courses in specified disciplines other than the major; and, other departments allow their majors to choose freely from "writing-intensive" courses across the college. Courses that satisfy the junior-year writing requirement may also satisfy major or distribution requirements.

Bachelor of Arts and Bachelor of Science Degrees

The curriculum in arts and science emphasizes a liberal education. It asks the student, in collaboration with the adviser, to select courses to satisfy three general categories, namely, distribution to insure breadth of education, a major field of concentration to provide depth, and free electives to provide breadth and depth to meet the student's needs.

A student electing to work for the bachelor of science degree may have a strong preprofessional orientation and will take more courses in the major field of concentration than will another in the bachelor of arts (B.A.) program. In all other respects the student in a bachelor of science curriculum meets the same requirements as the student in the bachelor of arts program.

The bachelor of arts and bachelor of science degrees require the completion of a minimum of 121 credit hours of collegiate work, apportioned to cover distribution and concentration requirements. A cumulative average of 2.0 or better in courses required in the student's major program and the completion of all general requirements apply to all candidates for baccalaureate degrees. A maximum of six credit hours of advanced military science or aerospace studies courses may be applied toward the degree.

Distribution Requirements for the B.A. and the B.S.

Distribution requirements are intended to ensure a breadth of learning without imposing undue restrictions on a student's course of study. Each distribution requirement may be fulfilled with a variety of courses, which can be chosen to complement the student's interests. No course applied to distribution may be taken pass-fail.

A College Seminar must be taken in the freshman year. This unique course allows students to study a subject of personal academic interest with an established faculty member who is an expert in the field. Seminars are limited to 20 students and encourage close interpersonal relationships with faculty and peers, heightened intellectual

engagement, and freedom to explore and discuss ideas as they arise.

- | | |
|--|---------------|
| A. A&S I, Choices and Decisions | 1 credit hour |
| (to be completed by the end of the first year) | |
| B. College Seminar | 3 hours |
| (one course during the first year) | |
| C. English Composition | 6 hours |
| (two courses during the first year) | |

The remaining distribution requirements should be completed by the end of the sophomore year. Courses taken within the major department to satisfy a major may not satisfy distribution requirements in more than one area.

- | | |
|---|------------|
| D. Mathematical Sciences | 3-4 hours |
| One course from mathematics and logical theory
(Philosophy 114 or 214). | |
| E. Sciences | 9-12 hours |
| Three courses from among those designated in:
astronomy, biological anthropology, biology,
chemistry, earth and environmental, geological
sciences, physics, and neuroscience.
At least one of the science courses must also include the
associated laboratory course. | |
| F. Social Sciences | 9-10 hours |
| Three courses from among those designated in:
anthropology, classics, economics, government,
history, international relations, journalism, psychology,
social psychology, social relations, sociology, STS, and
urban studies. | |
| G. Humanities | 9-12 hours |
| Three courses from those designated in: architecture,
art, classics, history, languages, literature, cultural
studies, music, philosophy, religion studies and
theatre. | |

Total required for graduation:	121 hours
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A student's program, including the choice of distribution requirements, is not official until approved by the adviser.

Foreign Language Study

Students who are planning on graduate study toward the doctor of philosophy degree are reminded that most graduate schools require Ph.D. candidates to demonstrate a reading knowledge of one or two foreign languages. Ability to use foreign languages is beneficial in many careers, such as law, journalism, commerce, industry, and government.

Centers and Institutes

The college participates in research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Center for International Studies, Center for Molecular Bioscience and Biotechnology, Center for the Application of Mathematics, Environmental Studies Center, Health Sciences Institute, Center for Innovation Management Studies, Center for Social Research, Emulsion Polymers Institute, Energy Research Center, Institute for Bioengineering and Mathematical Biology, Institute for the Study of the High-Rise Habitat, Lawrence Henry Gipson Institute for Eighteenth-Century Studies, Lehigh Valley Center for Jewish Studies, Materials Research Center, Sherman Fairchild Center for Solid-State Studies, The Stone Harbor Marine Laboratory, Technology Studies Resource Center, Zettlemoyer Center for Surface Studies.

Minor Programs in the College

Certain departments, divisions, and programs in the College of Arts and Science afford an opportunity to minor in an additional field of concentration other than the major field. (Please see the entry under the department you are interested in.) If a minor program is not listed under the

department desired, the student should consult the department chairperson.

A minor consists of at least fifteen credit hours; the specific content is determined in the department, division, or program concerned. A minor is optional and, if successfully completed, will be shown on the university transcript in the same manner as the major field of concentration. A 2.0 minimum grade-point average is required for courses in the minor. Because of this requirement, no course in the minor program may be taken with Pass/Fail grading. No more than one course may be double counted toward a major and a minor.

It is the responsibility of students desiring a minor to initiate it no later than the beginning of the junior year by filing a minor program with the department, division, or program where it is offered. The student's major adviser keeps appropriate records.

Minors in the College of Arts and Science departments and programs are available for degree candidates in other colleges within the university, with approval of their college adviser.

Following are established multidisciplinary minors in the College of Arts & Science.

Education Minor

The education minor helps undergraduates explore a career option in school teaching or other professional careers with elementary, secondary, or special-education students. The minor may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher-certification credits for those admitted to Lehigh's graduate-level Teacher Intern Program.

The minor offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual's understanding of education as a central intellectual phenomenon of our culture and to provide self-understanding of one's own potential as an educator.

An undergraduate may take one or all of these courses during the junior and senior years with the approval of the adviser. Completion of the minor does not assure admission to the Teacher Intern Program to become a certified professional. However, if the student passes the screening process on the basis of previous work and interviews, he or she may enter the intern program with advanced standing toward certification.

The program coordinators are Lynn Columba and Robert L. Light, Mountaintop Campus, 111 Research Drive.

Fifteen credit hours are chosen from among the following courses for those in the education minor:

- | | |
|----------|--|
| Educ 312 | Classroom Practice (1)
(must be taken concurrently with Educ 314) |
| Educ 314 | Intern Seminar (2)
(must be taken concurrently with Educ 312) |
| Educ 394 | Special Topics in Instruction and Curriculum (3) |
| Educ 429 | Child Development (3) |
| Educ 441 | Youth in Society (3) |
| Elective | Education course (appropriate to student's objective) (3) |

Communication Minor

Purpose: This minor guides students to a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, small group, dyadic, organizational and visual communication. It is particularly relevant to students interested in law, organizational communication, philosophy, government, marketing, or teaching.

The perspectives taken by the minor are those of

rhetorical theory and communication theory. The student will become acquainted with major theories, concepts and issues concerning the available means of persuasion, and with the techniques used to communicate successfully with others. Experiential learning includes the construction and delivery of oral presentations, writing, graphics and participation in small group and teamwork situations.

This minor is administered through the Communication Studies Program in cooperation with the Department of Journalism and Communication. An interdisciplinary committee of faculty members with both teaching and research interests in this area oversees the program. Students are encouraged to become involved with communication research activities under the guidance of interested faculty members.

Courses. The minor represents 18 credit hours or six courses. It consists of one required course in communication theory (chosen from Communication 143 or SPsy 135) and one required course in public speaking (Communication 130), and four elective courses. The student may satisfy the remaining four courses by either of two options. **Option 1** These four may be chosen from at least three of the groups below. One of the four elective courses must be 200-level or above. With the consent of the participating instructor and the director of the minor, a student may substitute a Special Topics project for one of these elective courses. **Option 2** Three of the courses may be chosen from three of the groups below, and the fourth may be a 3-credit internship in Journalism and Communication or in Art and Architecture, providing that the student meets all departmental requirements for such an internship.

The director is Dina Wills, Department of Journalism and Communication, University Center.

Required courses (6 hours)

Comm 130	Public Speaking (3)
Comm 143	Persuasion and Influence (3) or
SPsy 135	Human Communication

Elective courses (12 hours) chosen from at least three of the groups. One must be at the 200-level or above:

Group I—Public Communication

Comm 60	Fundamentals of Speech Communication (3)
Comm 331	Business and Professional Speaking (3)
Comm 144	Effective Interviewing (3)
Govt 329	Propaganda and American Politics
Jour 127	Public Relations Principles (3)
Jour 229	Public Relations Case Studies (3)
Jour 306	Applied Public Relations (3)
Mgmt 307	Business Communication Skills
Mktg 313	Marketing Communications
Mktg 316	Advertising

Group II—Communication in Writing

Engl 171	Practical Writing (3)
Engl 348	Theory and Practice in Writing (3)
Jour 123	Basic Science and Technical Writing (3)
Jour 128	Writing for Public Relations (3)
Jour 240	Writing for Broadcasting (3)

Group III—Interpersonal, Group and Organizational Communication

Comm 143	Persuasion and Influence
Mgmt 270	Organization Theory and Behavior (3)
Mgmt 321	Organizational Behavior Workshop (3)
Phil 113	Logic (3)
Psyc 121	Self and Others (3)
SPsy 125	Small Groups (3)
SPsy 135	Human Communication (3)
SPsy 312	Communication in Groups (3)
SR 118	Close Personal Relationships (3)

Group IV—Visual Communication

Art 43	Introduction to Graphic Communication (3)
Art 143	Graphic Communication II (3)
Art 231	Advanced Graphics (3)

Jour 141

Photojournalism (3) (Summer Semester only)

**Special Topics
Comm 325**

Special Topics in Communication (3)

Internships

(Consent of department required)

**Jour 361
Art 375**

Internship
Internship

Health and Human Development Minor

The minor in health and human development, located primarily within the College of Arts and Science, is an interdisciplinary program designed to provide insight into the social scientific aspects of health issues through the human life cycle. While this minor program is open to anyone in the three undergraduate colleges, it may be of particular interest to students preparing for careers in any aspect of health care, social work, and child or adult development.

The program is administered through the Program in Health and Human Development, an interdisciplinary group of faculty members who have research interests in this area. Current research studies cover all aspects of the life cycle, including the health dimensions of both normal and abnormal child development, reproductive health issues, adult life crises such as illness and loss, and dimensions of aging. Students are able to serve as research assistants in some of these studies.

The minor consists of a minimum of fifteen credit hours chosen in consultation with the program director, Donna Kosteva, in the office of career services.

required courses (6 credit hours)

Hist 8	History of Medicine in America (3) or
SSP 160	Medicine and Society (3)
and	
Psyc 107	Child Development (3) or
Psyc 108	Adolescent Development (3) or
Psyc/SSP 109	Adulthood and Aging (3)

elective courses (9 credit hours) chosen from three different disciplines:

Anth 321	Anthropology of Physical and Mental Health (3)
Govt 306	Public Policy Process (3)
Hist 8	History of Medicine in America (3)
Hist 337	History of Medical Thought (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)
Phil 116	Medical Ethics (3)
Psyc 77	Drugs and Behavior (3)
Psyc 107	Child Development (3)
Psyc 108	Adolescent Development (3)
Psyc/SSP 109	Adulthood and Aging
Psyc 305	Abnormal Psychology (3)
Psyc 351	Cognitive Development in Childhood (3)
Psyc 361	Personality & Social Development in Adulthood (3)
Psyc 363	Personality and Social Development in Childhood (3)
SSP 152	Alcohol, Science & Society (3)
SSP 160	Medicine and Society (3)
SSP 162	AIDS and Society (3)
SSP 333	Sociology of Aging (3)
SSP 341/WS 341	Women and Health (3)

Interpersonal Behavior in Small groups And Organizations

This minor has as its general focus the understanding of face-to-face interaction among human beings in small-group settings in a variety of organizational contexts. It will be relevant to students interested in personnel, the helping professions, group work, or any occupation requiring interpersonal skills in group settings.

The minor has both a cognitive and experiential learning dimension. Thus the student may become acquainted with

the major theories, concepts, and issues concerning interpersonal behavior in social contexts and also with some of the tools, skills, and insights that promote growth and competence in social interaction. Experiential learning also includes training in techniques of naturalistic observation of social interaction in small groups and organizations.

These courses are not arranged in a sequence; that is, while they individually may put more stress on the cognitive or experiential dimension, none are prerequisites for any other. Thus students may select any course, subject to the prerequisites and requirements of the university and the department, as well as availability.

The coordinator is Robert E. Rosenwein, Price Hall.

Fifteen credit hours are chosen from among the following courses for the minor in Interpersonal Behavior:

Mgt 321	Organizational Behavior (laboratory sections only) (3)*
Psyc 121	Encountering Self and Others (3)
SR 118	Close Personal Relationships (3)
SPsy 121	Social Psychology of Small Groups (3)
SPsy 135	Human Communication (3)
Anth 151	Utopias and Alternative Communities (3)
SR 395	Methods in Observation (3)
SPsy 312	Interpersonal Behavior in Small Groups (3)

Jewish Studies

The Jewish Studies minor offers students the opportunity to explore the history, literature, religion and social institutions of the Jewish people from its inception to the present. The diversity of courses highlights the interaction of Judaism with other world civilizations and the mutual influences between Judaism and societies and cultures of Europe, the Middle East, and the United States. Through the Jewish Studies minor, a student has the opportunity to study Judaism from the perspective of various academic disciplines.

The program is designed to be of interest to students with diverse interests and fields of concentration. The study of Jewish society and culture can enhance one's understanding of European or American society and culture. Students of psychology and sociology will find that Jewish Studies contributes to their understanding of such issues as prejudice and anti-Semitism, assimilation, and religious-cultural pluralism.

The study of Jewish religion and philosophy brings one face to face with such problems as God, religious faith and doubt, moral responsibility, evil and human suffering. In addition, studying Judaism in comparison with another religious tradition heightens one's understanding of both religions. The study of Judaism introduces the student of literature to a broad sample of diverse literary forms and themes from diverse periods and cultural settings.

The formal program of courses is augmented through a program of lectures, colloquia, films, and other cultural exhibits. Study abroad, particularly in Israel, is encouraged as a means to augment and broaden one's understanding of Jewish civilization. Under the sponsorship of the Philip and Muriel Berman Center for Jewish Studies, students may study for a semester or a year at the Hebrew University in Jerusalem or Tel Aviv University. During the summer, students may earn up to six credit hours by participating in the Tel Aviv University summer program, the Hebrew University summer study program in Jerusalem, the kibbutz-study program of the Hebrew University, or the Tel Migne-Ekron archaeological excavation. For further information on programs in Israel and scholarships available, students should contact Shirley Ratushny of the Berman Center. Students should coordinate their minor program in Jewish Studies with the director of the center, Laurence J. Silberstein, Maginnes Hall.

A minimum of fifteen credit hours is to be selected from the following courses. (A maximum of six credit hours of Hebrew may be counted.) In addition to the following courses, which are offered regularly, new courses are offered annually. Students should check with the Jewish Studies office, Maginnes 324, for an updated list.

Engl 312	Jewish Literature (3)
Hebr 1	Elementary Modern Hebrew I (3)
Hebr 2	Elementary Modern Hebrew II (3)
Hebr 11	Intermediate Modern Hebrew I (3)
Hebr 12	Intermediate Modern Hebrew II (3)
IR 81	Middle East in World Affairs to 1945 (3)
IR 82	Middle East in World Affairs Since 1945 (3)
MFL 61	Cultural Mosaic of Modern Israel (3)
MFL 62	The Israeli Struggle for Survival (3)
Phil 133	Medieval Philosophy (3)
Rel 73	Introduction to Judaism (3)
Rel 111	The Hebrew Bible/Old Testament (3)
Rel 112	Varieties of Judaism in the Greco-Roman World (3)
Rel 130	The Mystical Tradition: Judaism (3)
Rel 132	Hasidic Tales (3)
Rel 138	Women in Jewish History (3)
Rel/Anth 139	Jewish Folklore
Rel 150	Judaism in the Modern World
Rel 152	American Judaism (3)
RS/Hist 154	The Holocaust: History and Meaning (3)
Rel 155	Jewish Thought since the Holocaust (3)
Rel 156	Israel, Zionism, and the Renewal of Judaism (3)
Rel/WS 158	Sex and Gender in Judaism: The Feminist Critique (3)
Rel 172	The Jewish-Christian Encounter (3)
Rel 174	Contemporary Theology (3)
Rel 196	Judaism in Israel and the United States (3)
Rel 371	Directed Readings (1-3)
US 328	The American Jewish Community (3)

Latin American Studies

The minor in Latin American Studies represents an opportunity to explore the language, literature, history, cultures, and socioeconomic problems of our neighbors to the south. It provides a perspective on the problems of other underdeveloped regions of the world, in contrast to most offerings in the humanities and social sciences that usually focus on the mainstream of western culture, notably the United States and Western Europe.

It is worth noting the importance of Latin American cultures in the future of the hemisphere. Latin America is the most rapidly growing part of the world, and by the year 2000 it is predicted that the area will have a population of 600 million, or twice that of Anglo-America. Several countries, especially Brazil and Mexico, are undergoing rapid industrial expansion. Consequently, besides the personal values to be derived from this curriculum, there are business, governmental, and related career possibilities.

The minor program represents fifteen credit hours, or five courses, chosen from economics, history, government, Spanish, anthropology, and I.R. in discussion with the coordinator, James S. Saeger, history department, Maginnes Hall.

Requirement (3-6 hours)

Span 2 or MFL 51 and 53

Elective courses (9-12 hours) chosen from:

MFL 51	Contemporary Hispanic-American Literature (3)
MFL 53	The Hispanic World and Its Culture (3)
Eco 305	The Economic Development of Latin America (3)
Govt 322	Politics of Developing Nations (3)
Govt 335	Latin American Political Systems (3)
Hist 49-50	History of Latin America (3)
Hist 265	Mexico and the Caribbean (3)
Hist 266	Argentina, Brazil and Chile (3)
Hist 368	Seminar in Latin American History (3)
IR 136	International Relations in Latin America (3)
Anth 178	Mesoamerican Archaeology (3)
courses in Latin American literature, government or international relations (6)	

No more than six credit hours should be chosen from a given department.

Law and Legal Institutions

This program, based in the College of Arts and Science, is designed to foster interdisciplinary cooperation with the faculties of the other colleges in the university. The Law and Legal Institutions minor program is open to students from all three undergraduate colleges. Although the program may be of particular interest to some pre-law students, it should not be viewed as the preferred pattern, for those hoping to attend law school.

The program stresses the systematic analysis of contemporary legal institutions, coupled with an examination of their historical antecedents, especially those in the Anglo-American common-law tradition. The program also exposes students to both public and private law, and to courses using the traditional case methods as well as those of the social sciences and philosophy.

Each student's minor program is a coherent combination of courses individually and jointly designed by the student and the program director. To avoid unnecessary confusion, students are urged to declare their minor in Law and Legal Institutions by the end of their sophomore year.

Each minor program consists of five courses chosen from the following two categories, and shall include at least two courses from each category.

Category I—Case Method

Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
Jour 122	Media Ethics and Law (3)
Law 11	Introduction to Law (3)
Law 201	Legal Environment of Business (3)
Law 202	Business Law (3)
Phil 221/Law 221	Sex Discrimination and the Law (3)

Category II—Non-Case Method

Phil 113	Practical Logic (3) or
Phil 114	Fundamentals of Logic (3)
Clss 161	Roman Law (3)
Hist 360	American Constitutional and Legal History (3)
Phil 122	Philosophy of Law (3)
Psyc 81	Psychology and Law (3)
	Legal Research Special Topics (3)*

*This is a tutorial course taken by special arrangement with one of the faculty participating in the program. Students select a law related research topic, develop basic legal research skills and use these skills in the execution of a research project. The course number will vary, depending upon the departmental affiliation of the faculty person who supervises the research project.

For further information, consult the program director, J. Ralph Lindgren, philosophy department.

Russian Studies

The minor in Russian Studies is an interdisciplinary program designed to provide a broad range of study of the former Soviet Union. It can be considered the beginning of a specialization in the area that can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.). The program may also be of general interest to nonspecialist students who wish merely to do focused work on the culture and society of the former USSR.

The minor in Russian Studies requires eighteen to twenty-two credit hours of formal course work, chosen in consultation with the program director, Oles M. Smolansky, department of International Relations.

required courses (15-19 hours)

two semesters of college-level Russian (at least three credit hours each), based on the student's level of competence; **or**

two semesters of Russian literature in translation (6-10)	
Govt 361	Soviet and Post-Soviet Politics (3)
Hist 261	Russia to 1855 (3) or
Hist 262	Russia since 1855 (3)
IR 167	Diplomacy of Russia to 1945 (3) or
IR 168	Diplomacy of Russia Since 1945 (3)

elective course (3 credit hours); one course from the following: any other Russian-language course (3)

Eco 309 Comparative Economic Systems (3)

Govt 318 Communist Political Systems (3)

Hist 261 or 262 (whichever is not taken in the above section) (3)

IR 167 or 168 (whichever is not taken in the above section) (3)

IR 367 Seminar in the International Relations of Russia and Eastern Europe (3)

Special Topics courses in other areas such as psychology or social relations, with permission (3)

Field Study in the former Soviet Union for academic credit under Special Topics (3)

Other courses approved by the director of Russian Studies.

Science, Technology and Society Program

The Science, Technology and Society (STS) Program is a broad-based effort on the part of faculty members from all colleges to foster undergraduate courses concerned with the interrelationships between scientific and technological advancement and the quality of human life.

The STS Program offers a minor in Science, Technology, and Society Studies, consisting of fifteen credit hours drawn from a variety of departments. For a full description of the courses offered, see Section V.

Urban Studies

The minor program in Urban Studies is a means of gaining broad insight into the nature and potentialities of the social sciences, besides being an appropriate vocational choice for students in fields such as civil engineering, management, architecture, and social work.

Urban Studies is designed to promote basic understanding of social processes, so that students will learn to perceive in their communities opportunities for productive enterprises of their own. For some this will mean careers in public service, but others may contribute much to the betterment of society by successful work in the private sector. The minor in Urban Studies should be of particular interest to students in the College of Engineering and Applied Sciences as well as the College of Business and Economics who wish to maximize the educational value of their elective courses.

The minor consists of eighteen credit hours of course work selected in consultation with the program director, based on the needs and interests of the student with due concern for the overall intellectual coherence of the program.

Certain other courses in relevant disciplines may be included by permission of the director of urban studies, David Curtis Amidon, Jr., minor adviser, 232 Chandler-Ullmann.

required course (3 credit hours)

US 61	The Study of Urbanization (3)
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elective courses (15 credit hours); from the following:

Anth 128	Urban Ethnology (3)
Anth 151	Utopias and Alternative Communities (3)
Arch 210	20th-Century Architecture (3)
Arch 213	The City (3)
Eco 312	Urban Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 354	Public Finance: State and Local (3)
Govt 177	Urban Politics (3)
Govt 360	Public Administration (3)
Hist 333	American Urban History to 1885 (3)

Hist 334	American Urban History, 1880 to Present (3)
US 62	Contemporary Urban Issues (3)
US 125	American Ethnic Groups (3)
US 363	Philadelphia: Development of a Metropolis (3)

Soc 351	Gender and Social Change (3)
Soc 364	Lifestyle and the Family (3)
SR 41	Human Sexuality (3)
WS 272	Special Topics in Women's Studies (3)

In addition, new courses may be offered annually. Students should check with the Director for an updated list.

Women's Studies

The minor in Women's Studies engages students in the study of two interrelated subjects. The first is an examination of the cultural, historical, social experiences, and contributions of women. The second is an exploration of gender (i.e., the social construction of differential identity for males and females) and of the many ways in which gender distinctions have shaped human consciousness and human society.

Nearly all academic disciplines have defined human nature and significant achievement in terms of male experience and have underestimated the impact of gender on social structures and human lives. By contrast, Women's Studies courses attend to women's diverse experiences and perspectives and acknowledge the critical significance of gender. By shifting the focus to women and gender, Women's Studies seeks to provide an alternative paradigm for understanding human experience. Students in Women's Studies courses are encouraged to reevaluate traditional assumptions about human beings, human knowledge, and human culture and society, and to explore non-sexist alternatives for a more fully human social order.

The Women's Studies Program has several major goals: to expand students' understanding of women's present status and rich history; to stimulate a critical examination of the impact of gender roles and stereotypes on social structures and individual lives; to evaluate proposals for alternative arrangements; and to connect issues addressed in the classroom with those raised in personal, political, and cultural contexts. The program challenges students to think beyond the boundaries of traditional gender roles, traditional disciplines, and established institutions. In the best tradition of a liberal arts education, Women's Studies encourages women and men to think critically and constructively, to redesign knowledge, and to gain a better understanding of themselves and their world.

The minor in Women's Studies consists of a minimum of 18 credit hours (6 courses). Students pursuing the minor are required to take the introductory course (WS 101) and one upper-level course from among those concerned with the theory and practice of Women's Studies. The remaining 4 courses must include at least one course in the arts and humanities and one course in the natural and social sciences. Students arrange their program in consultation with the Program Director, Professor Lucy Gans, Department of Art and Architecture.

required courses (6 credit hours)

WS 101	Introduction to Women's Studies (3)
and	
WS 271	Independent Reading and Research (1-3)
	or
WS 330	Internship in Women's Studies (3) or
WS 350	Senior Seminar (3)

elective courses (12 credit hours)

Anthr 123	Cultural Construction of Gender (3)
Art 121	Women and Art (3)
Clss 152	Women in Antiquity (3)
Engl 311	Literature of Women (3)
Govt 179	Politics of Women (3)
Hist 124	Women in America (3)
Hist 325	American Social History, 1607-1872 (3)
Phil 126	Feminism and Philosophy (3)
Phil 221	Sex Discrimination and the Law (3)
Psyc 131	Psychology of Women (3)
Rel 127	Sex and Gender in Judaism: The Feminist Critique (3)
Rel 153	Sex and Gender in Religious Traditions (3)
Soc 341	Women and Health (3)

College Scholar Program

The College Scholar Program is intended to cater to students who show outstanding academic promise or unusual creativity, those whose interests are not satisfied by traditional programs, and those who are deeply committed to a particular subject. It is a highly selective program, restricted to a small number of especially qualified students, some of whom are enrolled at the time of admission and the rest in the following two years. Applications from entering freshmen are evaluated by the Admissions Office and the College Scholar Advisory Committee on the basis of their written statements of educational goals, high school records, college board test scores, and teachers' recommendations. Applications from freshmen and sophomores are evaluated by the Advisory Committee on the basis of their academic records and written statements of educational goals and recommendations from two faculty members.

The program allows students to devise individualized courses of study and to engage in scholarly work of an advanced nature. Participants are obliged to obtain 121 credits, including A&S1 and the junior writing requirement, take at least one college scholar seminar, and pursue departmental or interdisciplinary majors. With the approval of the program director, they design their own academic plans. They are released from distribution requirements and, if necessary, modifications may be made in major requirements. Responsibility for the student's over-all program lies with the director who cooperates closely with the major adviser. In each of the final two semesters, the student receives up to six credits for work with a faculty member, leading to a senior project of substantial dimensions. This can take whatever form is appropriate to the nature of the subject. Students present accounts of their projects at the annual college scholar graduation dinner. The award of the College Scholar graduation honors is subject to the recommendation of the program director and the chairperson in the major field.

In addition to the academic privileges of the program, college scholars are offered a variety of extracurricular opportunities. These include invitations to meet visiting speakers, informal meetings with faculty members, dinners throughout the year, lectures, plays, musical events, and other cultural activities in the Lehigh Valley and nearby cities.

College Seminar Program

During the fall or spring semester of the freshman year, every freshman student in the College of Arts and Science is required to enroll in a college seminar taught by a member of the faculty. With ten to twenty students per class, these seminars provide an intimate and supportive environment that facilitates the transition to university life. Students begin to develop many of the skills that serve as a framework for their future scholarly work—how to read closely, think critically, write clearly, learn cooperatively, speak persuasively, and solve problems creatively.

College seminars are an excellent way to explore a subject that may be new, or to enter more deeply into an area of previous interest. Many of the topics are non-traditional or interdisciplinary subjects of special interest to the professor. Recent offerings have included: "The Jazz Age," "The Death of Western Civilization," "Cosmic Physics," "The Soviet Collapse and Russia's Future," "Fate and Character," "AIDS and Society," "Acting," "In Search of Big Foot."

Whatever the topic, seminars involve considerable effort on the part of students. Some classes emphasize reading assignments, papers, and oral presentations; others include tests, laboratory work, or fieldwork. Each 3-credit seminar

fulfills the College Seminar requirement but does not fulfill any distributional requirements.

Pre-Law Programs

The university has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have a prescribed pre-law program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula in all three of the undergraduate colleges. Law-related courses, some of which rely on the case method, are provided by both the College of Arts and Science and the College of Business and Economics. These courses are open to all students, including those in the College of Engineering and Applied Science. Illustrative courses in Arts and Science include Constitutional Law, Media Ethics and Law, and Philosophy of Law. Correspondingly, there are courses such as Introduction to Law and Legal Environment of Business in the College of Business and Economics. That college also offers basic accounting courses which are often recommended as part of an undergraduate's pre-law preparation. In addition to formal academic instruction, Lehigh provides opportunities for gaining academic credit in several off-campus programs which provide practical experience in law and public affairs.

A student-run Pre-Law Society brings members of the legal profession on campus to discuss legal specialties, admissions, and career opportunities. Counseling is available to prospective prelaw students on a continuous basis from freshman orientation through the law school application process in the senior year. An advisory committee, composed of faculty members and the pre-professional advisor in Career Services, coordinates these pre-law counseling services. Students are urged to consult members of this committee as early as possible in their academic careers.

Details on the Law and Legal Institutions minor program are found elsewhere in this section of this catalog.

Health Professions Programs

Schools of medicine, dentistry, and veterinary medicine stress the importance of a strong liberal arts education as well as prescribed studies in the sciences. Although most pre-health students will choose a major in a pure or applied science, as long as candidates have the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes a pre-professional advisor and faculty members from biology, chemistry, engineering, and physics, provides career and academic counseling and works closely with students throughout the process of applying to professional schools.

An active student-run health professions society brings to campus guest lecturers in a variety of health related fields.

Students interested in optometry, pharmacy, podiatry, physical or occupational therapy and other allied health fields may obtain information from the health professions advisory committee in planning their courses with their academic advisers.

Accelerated M.D. Program

In cooperation with the Medical College of Pennsylvania, the university offers an accelerated six-year program that enables selected students to earn both the bachelor of arts degree in premedical science and the M.D. degree after a minimum of six years of study at the two institutions. The program was initiated in 1974, and approximately fifteen students are admitted each year.

The program includes two academic years and two summers at Lehigh, during which time ninety-one credit hours are earned toward the 121 credits required for the baccalaureate degree. Students entering Lehigh with sufficient advanced placement credit may reduce or entirely eliminate the second summer session. The program also offers the flexibility of a third year at Lehigh to pursue additional course work or extracurricular activities. (Please

refer to the sample array of course sequencing shown below.) The next four years are spent in the regular program of medical education at MCP in Philadelphia. After successfully completing the first two years at the medical college, students will have acquired the necessary additional credit hours for the baccalaureate degree.

During the first two years at Lehigh, students are expected to make satisfactory progress in academic areas as well as in the more subtle task of personal growth in those attributes ultimately needed as a physician. MCP receives student grades and monitors student progress through feedback from Lehigh staff. Students are expected to maintain an overall grade point average of 3.4 or better (A=4.0) and no grade(s) less than a "C". Credentials again will be processed through MCP's Admissions Committee prior to extending a final definitive acceptance. This program also requires that students take the Medical College Admissions Test. The results will be evaluated by the Committee prior to final acceptances. It is expected that the three numbered scores be "9" or better on the 1-15 scale.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student's academic or personal maturation. In addition, the student may elect to take additional time at Lehigh if he or she feels that this would be beneficial. Should this occur, the student would be eligible to defer matriculation at the medical school for a period of time agreed to by the student and the medical college.

Application for admission to the program is made through the Lehigh office of Admission. Criteria for admission include SAT scores (minimum combined score of approximately 1300), achievement tests in Math II, English Composition, and Chemistry, scholastic achievement, maturity, and motivation for medicine.

Completed applications are reviewed by the Office of Admissions, and a pool of students are chosen for interview by the Medical College.

Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of this program. Application deadline is December 1.

Year 1: Lehigh, fall	spring
A&S 1 (1)	Engl 2 (3)
Engl 1 (3)	EES 31, 32 (4)
Chem 21, 22 (5)	Math 22 or 44 (3-4)
Math 21 or 41 (3-4)	Social Science (3)
Humanities (3)	Freshman Seminar (3)

Summer 1: Lehigh
Chem 51, 53 (4)
Chem 52, 58 (4)
Elective (free) (3)
Elective (free) (3)

Year 2: Lehigh, fall	spring
Phys 11, 12 (5)	Phys 13, 14 (4)
MBIO 31, 32 (4)	Chem 31 (3)
Math 23 or Math elective (3-4)	MBIO 101, 102 (4)
Humanities (3)	Social Science (3)
Elective (free) (3)	Writing Intensive (3)

Summer 2: Lehigh
Humanities (3)
Social Science (3)
Elective (free) (3)

Accelerated Program in Dentistry

The university, in cooperation with the School of Dental Medicine at the University of Pennsylvania, offers an accelerated program that enables selected students to earn a combined baccalaureate and doctor of dental medicine degree after a minimum of seven years of study at the two institutions.

The program includes three academic years during which time ninety-two credit hours are earned toward the

baccalaureate degree. (Please refer to the sample array of course sequencing shown below.) The next four years are spent in the regular program of dental education at the School of Dental Medicine in Philadelphia.

During the first three years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the areas of personal growth, developing those attributes ultimately needed to become a dentist. Students must maintain a minimum 3.0 grade-point average throughout their three years at Lehigh.

The dental school reserves the right to withdraw an acceptance if academic or personal concerns cause the college to question a student's ability to function as a dentist. The dental school also reserves the right to require that students spend additional time at Lehigh if the school feels that this is necessary to insure the student's academic or personal maturation.

Application to the program occurs when a student applies to Lehigh University. The dental school takes action on the applicant in the spring of an academic year. Final decisions are forwarded to Lehigh University about March 20. The applicant is notified of joint acceptance by Lehigh University. Admission is based on SAT scores (a minimum combined score of 1200), scholastic achievement, maturity, and motivation for dental school. Application deadline is January 1.

Year 1, fall	spring
A&S 1 (1)	Engl 2 (3)
Engl 1 (3)	Math 44 (3)
Math 41 (3)	EES 31, 32 (4)
Chem 21, 22 (5)	Freshman Seminar (3)
Humanities (3)	Social Science (3)

Year 2, fall	spring
Chem 51, 53 (4)	Chem 52, 58 (4)
MBIO 31, 32 (4)	MBIO 101, 102, (4)
Humanities (3)	Social Science (3)
Elective (free) (3)	Elective (free) (3)

Year 3, fall	spring
Phys 11, 12 (5)	Phys 13, 14 (4)
Life Science elective (3)	Life Science elective (3)
Humanities (3)	Chem 31 (3)
Writing Intensive (3)	Social Science (3)
Elective (free) (3)	Elective (free) (3)

College of Business and Economics

James W. Schmotter, *dean*; Therese A. Maskulka, *associate dean, director of undergraduate programs*; Kathleen A. Trexler, *assistant dean, director MBA program*

The College of Business and Economics offers the bachelor of science degree in business and economics, which couples a liberal educational background with an understanding of the complexities and processes of management. It can serve as the basis for a career in business or for professional studies in fields such as law, business, or related fields.

The undergraduate business program, undergraduate accounting program, and MBA program are accredited by the American Assembly of Collegiate Schools of Business (AACSB), of which the College of Business and Economics is a member. The college offers a program of undergraduate study designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human and physical resources. The study of business and economics provides a basis for understanding and developing solutions to these problems.

Thus the college's undergraduate business program stresses analytical and communication skills, and problem-

solving techniques. Educational breadth equivalent to many liberal arts programs is accompanied by in-depth study of business processes such as accounting information systems, financial flows and markets, management processes, and the impact of economic forces upon business and social issues.

Goals of the College

The objectives of the College of Business and Economics are to provide an understanding (at the undergraduate level) and managerial and/or research expertise (at graduate levels) of the nature of business enterprise decision-making and resource management in the economy. Undergraduate objectives may be summarized as follows:

- Through a common body of knowledge, to stimulate interest in and acquaint a student with basic business and economic systems of resource allocation, financial management, management of human and physical resources, information systems, financial and managerial accounting, pricing and distribution;
- To provide breadth of appreciation of the scientific, technological, social, and human features of the world in which business is carried on;
- To provide tools which permit rigorous analysis of business problems and to foster a capacity for continuing professional development;
- To undertake advanced courses with upperclass students as a prelude to a professional career or to graduate study;
- Through a major, to provide each student with an in-depth learning experience in at least one area of business or the economy in which business operates, such as accounting, economics, economic statistics, finance, foreign careers, management, or marketing;
- To increase written and oral communication skills.

Breadth of Study

The undergraduate education deemed most suitable for young men and women who will be the business leaders of tomorrow combines broad educational foundations, analytical rigor and in-depth understanding of business operations.

This education in fundamental principles, and problem-solving techniques provides graduates with various options. Some of the students choosing this curriculum have already settled upon business careers. Others will use it as a base for further professional studies in law, graduate business schools, or specialized graduate training in economics, operations research, or other related fields. Still others go into administrative careers in government or nonprofit institutions such as hospitals and universities. Others apply their talents to professional accounting, financial investment, or management consulting careers. Others teach economics or administrative science.

Business today cannot be approached with narrow or superficial vocational training. Its problems are strongly conditioned by the state of the economy, a complex array of international aspects, and other major social and ethical issues. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. The student also must be familiar with physical sciences and technology. Finally, mathematics and computer systems are essential elements of modern decision-making processes. An introduction to all of these is provided in the undergraduate program in business and economics.

The six college departments in which much of the student's work is carried out are: accounting, economics, finance, law and business, management, and marketing.

Variety of Options

The student of today must be provided with options. Initiative and motivation would be discouraged in a rigid curriculum. To avoid such rigidity, the necessary exposures to science, language, and other arts are accomplished by distribution requirements, within each of which the student has wide choice. In addition, students have 24 credits of free electives, 15 of which *must* be taken outside the College of Business and Economics.

The degree of bachelor of science in business and

economics may also lead to achievement of the master of business administration degree at Lehigh or another institution. In addition to the master of business administration, the college also offers the following graduate degrees: doctor of philosophy, master of arts, master of science, master of science in management science, and master of science in management of technology. These are described in Section IV.

Centers and Institutes

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Diamond Center for Economic Education, Center for Innovation Management Studies, Center for Social Research, Martindale Center for the Study of Private Enterprise, Institute for the Study of Commodities, Philip Rauch Center for Business Communications, Goodman Center for Real Estate Studies, and Musser Center for Entrepreneurship.

The college is also associated with the Center for International Studies, and the Iacocca Institute.

Bachelor of Science in Business and Economics

To obtain the bachelor of science degree in business and economics, 120 credit hours are required. A writing requirement, which is included within the required 120 credit hours, is also a part of the college curriculum.

College Core Requirements (60 credits)

English and mathematics (12 credits)

Engl 1	Composition and Literature (3)
Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Math 41	BMSS Calculus I (3)
Math 44	BMSS Calculus II (3)

(BMSS denotes for Biological, Management and Social Science.)

Business and economics core (48 credits)

Eco 11	Principles of Microeconomics (3)
Eco 12	Principles of Macroeconomics (3)
Mgt 1	Introduction to Business Computing (3)
Eco 115	Applied Microeconomics (3)
Eco 145	Statistical Methods (3)
Eco 229	Money and Banking (3)
Acct 151	Introduction to Financial Accounting (3)
Acct 152	Introduction to Managerial Accounting (3)
Acct 211 or Acct 311 (3)	Management Information Systems in Business (3) or (Accounting majors will take Accounting 311 as part of their major program.)
*Mgt 175	Quantitative Methods (3)
Law 201	Legal Environment of Business (3)
Mkt 211	Contemporary Marketing (3)
Fin 225	Business Finance (3)
Mgt 269	Management of Operations in Organizations (3)
Mgt 270	Organization Theory and Behavior (3)
Mgt 301 or Mgt 306	Business Management Policies (3) or Entrepreneurship and Business Policy (3)

*Waived for the class of 1996 and undergraduates entering the College of Business and Economics in the fall of 1992.

Major Program (15 credits)*

Before the end of the first semester of the junior year, students select a major consisting of sequential or related

courses in one of the five major programs: accounting, economics, finance, management, and marketing.

A grade point average of 2.0 or higher in the major program is required for graduation.

*The major in accounting, which includes Accounting 311, consists of 18 credits.

Distribution Requirements (21 credits)

Students are required to earn a total of 21 credits from courses that provide substantial exposure to each of the following areas: humanities, science, and social sciences. Students will be notified as to which course offerings may be taken to satisfy this requirement.

Electives (24 credits)

Students will earn 24 credits of "free" electives — of which a maximum of six credits may be approved 300-level economics courses, a maximum of nine credits may be taken from other coursework in the College of Business and Economics, and a minimum of nine credits must be taken outside the College of Business and Economics. As another alternative, all 24 credits may be taken outside the College of Business and Economics.

Students will also earn 9 credits of completely free electives. Courses taken to satisfy this requirement may be taken in any college including the College of Business and Economics.

Planning Courses of Study

In addition to freshman English and mathematics requirements, each freshman enrolled in the College of Business and Economics registers for Eco 11 and Eco 12. The College of Business and Economics assigns students to take Mgt 1 in either the fall or spring semester of their freshman year. Those students that take Mgt 1 in the fall semester will take Eco 145 (Statistics) in the spring semester of their freshman year. Those students who take Mgt 1 in the spring semester of their freshman year will take Eco 145 in the fall semester of their sophomore year. Students are encouraged to consider substituting Math 21 and 22 for the Math 41 and 44 requirement because Math 21 and 22 are prerequisites for many courses in engineering and science. Acctg 151 is taken in the first semester of the sophomore year.

Freshman Year			
	first semester		second semester
Engl 1	3 credit hours	Engl 2	3 credit hours
Math 41	3	Math 44	3
Eco 11	3	Mgt 1 or Eco 145	3
Mgt 1	3	Eco 12	3
elective	3	elective	3
elective	15 credit hours	elective	15 credit hours

The pass-fail option is available for students in the college for elective courses only. Students desiring to obtain Lehigh credit for courses taken at other institutions must obtain a petition form from the registrar's office and obtain the approval of appropriate Lehigh academic departments *in advance*.

College of Education

The university's College of Education offers opportunities for advanced study in the field of education. For information, see Graduate Study in Education, Section IV, or College of Education, Section V.

College of Engineering and Applied Science

Sunder H. Advani, *dean*
Kenneth N. Sawyers, *associate dean*; Harvey G. Stenger,
associate dean

The College of Engineering and Applied Science offers the bachelor of science degree in thirteen programs, combining a strong background in sciences and mathematics with General Studies requirements in humanities and social sciences. Students in college programs learn principles they can apply in future professional work; those who plan on further academic experience can design a curriculum centering on interests they will pursue in graduate school.

In the past, engineering education was identified in terms of the needs of industry. Present-day engineering programs continue to provide and emphasize such preparation. However, the flexibility inherent in the curricula enables students to design personalized programs leading directly into other professional colleges or professions such as medicine, law, government, management, or architecture. The college encourages such mobility.

Experience shows that the background provided through the college programs, including "the engineering approach" to identification, articulation and resolution of problems, finds increasingly wider applicability in those areas of activity that call for a combination of practical and conceptual intelligence.

The college recognizes that the four-year programs are not intended to train specialists in a given area but rather to educate students in terms of principles they will apply to problems they encounter in future professional work.

The applied curricula of the college stress fundamentals while providing opportunities for electives in each of the substantive fields within the sciences. Senior-year programs in the sciences can be planned to facilitate transition to either graduate school or industrial laboratories.

Major Subjects

The College of Engineering and Applied Science includes six departments and offers undergraduate and graduate degree programs at the bachelor, master, and doctor of philosophy levels.

The undergraduate degree programs or curricula leading to the bachelor of science degree are:

biochemistry
chemical engineering*
chemistry
civil engineering*
computer engineering*
computer science**
electrical engineering*
engineering mechanics
engineering physics
fundamental sciences
industrial engineering*
materials science and engineering*
mechanical engineering*

*Accredited by the Accreditation Board for Engineering and Technology. Programs in chemistry and physics have been approved by the program review committee in these disciplines.

**Accredited by the Computing Science Accreditation Board, Inc.

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering sciences, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum requires study in humanities and social sciences (HSS).

Declaration and Change of Curriculum

The early indication of curriculum choice by students in their application to the university is not an irrevocable commitment on their part. In the second semester of the freshman year, at preregistration for the sophomore year, students usually indicate their choice of curriculum.

However, since the sophomore year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by means of a petition following consultation with curriculum advisors. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

Undergraduates with interests in such topical areas as environmental control, biotechnology, or aerospace may pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and are usually taken during the senior year.

Free Electives

The college, through its advisers, is prepared to help students to use the credit hours of "free electives" that, along with other electives in the curriculum, may be used to develop a program of personal interest. Free electives may be satisfied by taking regular course offerings or up to six credit hours from Mus 21-78, or up to six credit hours from Jour 1-8, or up to six credit hours of advanced ROTC courses.

Students who do a co-op assignment or have significant involvement in noncredit major extracurricular activities may have up to six credit hours of free electives waived upon petition to the department chairperson. These petitions must be completed and approved *prior* to the final semester before graduation.

Qualified juniors in the college planning to continue their formal education in graduate school are urged to take advantage of the flexibility in their programs and design their senior-year "free elective" opportunities in a manner that provides an effective foundation for a graduate program. Students who plan their programs in this manner can, upon recommendation of the department and with the approval of the dean of the Graduate School, receive credit toward their degree for up to six hours of graduate-level courses.

Technical Minors

Minors are offered in technical or scientific specialties that are not normally included within the standard curricula. Each program contains at least fifteen credit hours of technical and/or scientific courses. Often these courses can be chosen as approved electives in the student's major curriculum; others are chosen as free electives.

Technical and scientific minors are available in chemical processing (not open to chemical engineers), molecular biophysics (not open to engineering physicists or fundamental sciences majors concentrating in this area), production management (not open to industrial engineers), fluid mechanics, and solid mechanics.

In some special cases a student in the college who is able to incorporate electives within the curriculum that satisfy the requirements of a minor offered in the College of Arts and Science may, with the permission of the adviser in that college, earn the minor.

Recommended Freshman Year In Engineering and Applied Science

A recommended outline of work for the freshman year, which satisfies requirements for all students in the college, is

shown below. For schedules of the work required in the following three years, refer to Section V.

Freshman year, first semester (15-16 credits)

Engl 1	Composition and Literature (3)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5) or
Phys 11, 12	Introductory Physics I and Laboratory (5)
Math 21	Analytic Geometry and Calculus I (4)
Engr 1	Engineering Computations (3) or
HSS	Humanities, or Social Science
elective (3 or 4)	elective (3-4)

Freshman year, second semester (15-16 credits)

Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Phys 11, 12	Introductory Physics I and Laboratory (5) or
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Math 22	Analytic Geometry and Calculus II (4)
Engr 1	Engineering Computations (3) or
HSS	Humanities, or Social Science
elective (3 or 4)	elective (3-4)

Humanities/Social Sciences

Each student in the college is expected to complete a minimum of twenty-four credit hours of course work in humanities and social sciences. This Humanities/Social Sciences (HSS) requirement is designed to enable students to explore value systems, assumptions, and methodologies of an area of the humanities or the social sciences and to obtain some breadth of exposure to subjects in these areas. The criteria under which programs in the college are accredited include the requirement of both breadth and depth of study in areas of humanities and social sciences.

Nine credit hours of the HSS component of the curriculum are:

- English 1 (or equivalent) (3)
- English 2 (or equivalent) (3)
- Economics 11 or 12 (3)

The remaining fifteen credit hours of humanities and social sciences (five courses) are selected by the student as electives from three options described below that provide breadth and depth of study as well as flexibility to suit a wide range of personal interests. One of these options must be selected when the engineering major is declared (usually at the end of the freshman year).

Option 1: Complete five courses, including:

Three courses, subject to exceptions listed below, in one of the humanities or social sciences departments. (See listings under Bachelor of Arts degree Programs in Humanities or Social Sciences given on page 25 of the catalog.) At least one of the courses must be at the 100 level or above.

Two additional courses from the list of HSS electives under Option 2, below, in departments other than the one selected above. These two additional courses must not be in, or crosslisted with, the chosen department.

The following courses are *not* acceptable HSS electives (See Note 1):

- Architecture 147, 351, 352
- Economics 101, 145, 351, 352, 357
- English, all freshman composition courses, 171, 172, 173
- Government 313, 314
- Journalism 1 through 12, 113, 123, 128, 129, 141, 214, 215, 220, 229, 231, 233, 240, 306, 311 through 315, 361
- Communications 144, 325, 331
- Music 11, 12, 13, 15, 21 through 78, 82, 213, 215, 253 through 291
- Philosophy 113, 114, 214
- Psychology 110, 121, 171, 177, 210, 343, 377-399

Theater 61, 111, 116, 161 (petition required for Thtr 175 or 351)

These courses, although not qualifying as HSS electives, may be taken as free electives.

Option 2: Complete five courses, including:

Three courses in one of the following interdisciplinary areas, with at least one course being at the 100 level or above, plus one course in each of the other two areas. Each of these latter two courses must not be crosslisted with any courses in the selected interdisciplinary area. No more than three courses may be in any single department. (See Note 1)

(a) *Values and Contemporary Society*—Courses that treat the interrelationship of values and contemporary social, personal or professional life.

- Cognitive Science 7, 140
- Communications 143
- Economics 12 or 11 (see Note 2), 105, 119, 311, 312, 314, 315, 334, 335, 336, 353, 354, 368
- Government 111, 115
- History 339, 340
- Journalism 122, 124, 125
- Management 270, 301
- Philosophy 105, 115, 116, 117, 122, 123, 124, 126, 205, 221, 251
- Religion Studies 127, 133, 134, 153, 163
- Science, Technology and Society 11, 12, 121, 124, 341
- Sociology/Social Psychology, any course
- Social Relations 41, 118, 331
- Urban Studies, any course

(b) *Western Civilization*—Courses treating the history, development or the current state of the social ideas, institutions or practices of Western culture.

- Architecture 103, 176, 206, 207, 210
- Anthropology 174, 176, 180
- Art 1, 2, 82, 121, 179, 220, 222
- Classics, any course
- Economics 303, 305, 309, 310, 313, 331, 332
- English, any literature course
- Government, any course except non-Western
- History 7, 8, 111, 145, 180, 301, 315, 337, 361, 363
- International Relations, any course except non-Western
- Journalism 135
- Law 11
- Modern Foreign Languages, any foreign language except Chinese or Japanese
- Philosophy 1, 10, 122, 123, 124, 126, 128, 131, 133, 135, 139, 220, 221, 237, 239, 250, 251
- Religion Studies 73, 104, 108, 111, 114, 121, 154, 180, 222
- Sociology/Social Psychology, any course
- Science, Technology and Society 145
- Urban Studies, any course

(c) *Non-Western Civilization*—Courses treating the history, development or current state of the ideas, institutions or practices of non-Western cultures or societies.

- Anthropology, any course
- Classics 204
- East Asian Studies, any course
- Government 3
- History 5, 31
- International Relations 10, 33, 61, 81, 82
- Journalism 221
- Modern Foreign Languages, Chinese or Japanese language
- Religion Studies 107, 115, 117, 118, 119, 136, 164, 166, 220, 221
- Science, Technology and Society 141

Option 3: For greater emphasis in a particular area, a student may choose to complete a minor in Humanities and Social Sciences (HSS). Specific requirements may be found on page 25 of the catalog under the heading *Minor Programs in the College*. Excluded are minors in Education and

Communications, and included is a minor in Economics. (See page 25.)

To preserve breadth of study, a student electing a minor in HSS must take two additional HSS courses listed under Option 2 that are not in or crosslisted with courses in the minor or in the department sponsoring the minor. Because this will result in taking as many as seven HSS courses, a student electing Option 3 must use personal (free) electives. Each curriculum in the College contains a minimum of two such unrestricted electives.

Written permission to pursue a minor in HSS must be obtained from the sponsoring department, approved by the student's engineering faculty advisor and the Director of HSS, and filed with the Registrar. A student who elects a minor but fails to complete it must satisfy Option 1 or Option 2 above in order to fulfill the HSS program requirements for graduation. A student successfully completing a HSS minor will receive a certificate in recognition of this accomplishment.

NOTE 1: Although designations of courses by name and/or number are believed to be accurate, students are cautioned to consult with the Director of HSS Studies, College of E.A.S. Dean's Office, or the Registrar for corrections of, additions to, or other variations in the published lists. A course consisting largely of quantitative methodology, technical material, or narrowly vocational skill acquisition is not suitable for inclusion in the HSS category.

NOTE 2: If Eco 11 is taken to satisfy the economics requirement, then Eco 12 may be taken as an HSS elective; or vice versa. The combination of Eco 11 and 12 is a prerequisite for economics courses numbered 100 or greater.

NOTE 3: Language study, if elected, must consist of any advanced course, or at least one full year in one language at the elementary/intermediate level. Placement at the appropriate level is determined by the Modern Foreign Language department. A student may not elect an elementary course in any language studied in high school without approval of that department.

Centers and Institutes

Faculty and students in the college also have research and scholarship activities in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Bioprocessing Institute, Center for Design and Manufacturing Innovation, Center for Environmental Studies, Center for Health Sciences, Center for Innovation Management Studies, Center for Molecular Bioscience and Biotechnology, Chemical Process Modeling and Control Center, Emulsion Polymers Institute, Energy Research Center, Fritz Laboratory, Institute for Robotics, Institute for the Study of the High-Rise Habitat, Institute of Fracture and Solid Mechanics, Institute of Metal Forming, Institute of Thermo-Fluid Engineering and Science, Materials Research Center, Sherman Fairchild Center for Solid-State Studies, Zettlemoyer Center for Surface Studies.

Special Undergraduate Academic Opportunities

The academic programs in the colleges are supplemented by five-year, two-degree programs as well as opportunities for advanced, foreign, and experiential study.

Arts-Engineering Option

The curriculum in Arts-Engineering is designed for students wanting a professional education in a field of engineering and also the opportunity to study a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However,

the first three years of science and engineering courses are scheduled over four years for the arts-engineer. During this period the arts-engineer is a student in the College of Arts and Science pursuing a bachelor of arts or bachelor of science major program.

In many instances it may be advisable to take the two degrees at the end of the fifth year. Arts-engineers working towards the bachelor of science in biology, computer science, environmental science, geological sciences, geophysics, molecular biology, and statistics are advised to pay special attention to the engineering Humanities and Social Science requirements, which must be met in time for the student to qualify for the B.S. in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate (B.S. or B.A. degree only) in the colleges.

Bachelor/Master Degree Programs

Of increasing interest to undergraduates are the two-degree programs that may lead to both a bachelor and a master's degree in five years. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the arts/master of business administration degree and the engineering/master of science in materials degree, among others. The fifth-year program in the School of Education enables those receiving a B.A. degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, secondary teachers can receive the master of arts and elementary teachers can receive master of education degrees.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Arts/M.B.A. Program

Students in the College of Arts and Science may enroll in a special arts/master of business administration program by completing the 43 credit hours of courses listed below in the suggested sequence, while completing their major in one of the B.A. programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their M.B.A. degree upon completion of an additional 36 hours of course work. This can usually be accomplished in two regular semesters and two summer sessions.

All courses listed below under "other required courses" must have a grade of B minus or better in order to be credited toward the M.B.A. program.

The following comprise the required courses during the four years in the college:

required background courses

- * Eco I Economics (4)
- * Math 41 BMSS Calculus (3) **and**
- * Math 44 BMSS Calculus II (3) **or**
- * Math 21 Analytical Geometry & Calculus (4) **and**
- * Math 22 Analytical Geometry and Calculus II (4)
- * Mgt 1 Intro to Business Computing (3)

other required courses

- ** Eco 145 Statistical Methods (3) **or**
- IE 121 Applied Engineering Statistics (3) **or**
- ** Math 231 Probability and Statistics (3)
- ** Acctg 151 Essentials of Accounting (3)
- ** Acctg 152 Essentials of Accounting (3)
- ** Eco 119 Macroeconomic Analysis (3)
- *** Acctg 324 Cost Accounting (3)
- *** Mgt 302 Quantitative Models—Conceptual (3) **or**
- IE 222 Operations Research-Deterministic Models (3)
- *** Law 201 Legal Environment of Business (3)
- *** Eco 229 Money and Banking (3)

- * recommended in the freshman year
- ** recommended in the sophomore year
- *** junior standing required for this course

Note: Students who do not take Acctg 152 and Acctg 324 as undergraduates will be required to take Acctg 413 as part of their M.B.A. coursework; and students must take both Eco 119 and Eco 229 to waive Eco 409.

Engineering-M.B.A. Program

The bachelor in engineering-master of business administration two-degree program is designed to meet the needs of especially competent students in any engineering curriculum who want to add to their engineering studies training in business management at an advanced level.

The time involved will vary depending on the student's background. One or more summer sessions in addition to two or more regular semesters of study may be necessary after completion of the bachelor's degree in engineering to attain the M.B.A. or M.S. in management science. All candidates must take the Graduate Management Admission Test and must meet the standards for admission into The Graduate School.

For background courses required for the master of business administration program, engineering students should read Section IV, Graduate Study in Business and Economics, and consult with Kathleen Trexler, Assistant Dean and MBA Director, College of Business and Economics.

Interdisciplinary Programs

The university's interdisciplinary programs are designed to cross the boundaries between colleges to accommodate new and developing fields as well as the interests of students. They include such programs as the following:

Afro-American Studies. A program offering a minor is available to students interested in exploring various aspects of the African American experience. Courses covering African American art, history, literature, music, and society are offered. The program is complemented with a lecture, film, and arts series that highlights the richness and diversity of black culture.

Law and Legal Institutions. This minor program involves eighteen credit hours of course work in the College of Arts and Science and the College of Business and Economics and is available to students enrolled in all three colleges.

Science, Technology and Society Program (STS). Faculty from all three colleges explore the interrelationships between science and technological advancement and the quality of human life in the popular STS program.

Interdisciplinary Technology Courses. Several courses have been developed to make students better aware of an understanding of the role that science and technology play in society. They are intended primarily for non-science and non-technology students, but science and engineering majors may also take them. None of these courses may be used to satisfy distribution or general studies requirements. These courses are taught by faculty from the College of Arts and Science and the College of Engineering and Applied Science. Course numbers may vary by semester; consult STS Program or College Dean's offices for specific details.

International Programs at Lehigh

The University International Mission Statement states: "The University emphasizes the development of future leaders in our global society as first among Lehigh's purposes. Lehigh fosters an environment that welcomes and encourages international exchange of students and scholars, and that integrates their global experience into the academic and cultural domains. Lehigh is committed to the concept that a great university enhances its teaching, builds its scholarly

standing, and augments its service to society by providing an international dimension to each of these main functions."

To fulfill this mission statement, Lehigh offers a variety of programs in international studies and a variety of services for international students. This section is your guide to courses and services offered.

Study Abroad - Semester and Year

Study abroad can provide a rich educational and cultural experience for Lehigh students. To ensure a quality education during study abroad, the university has determined that students will be able to receive Lehigh academic credit or participation in only approved programs. The programs on the approved list, currently numbering over fifty, are regularly evaluated and monitored by the University Committee on Study Abroad, the body delegated this task by the University Faculty.

The main university contact person for students interested in study abroad is the Study Abroad Coordinator, in the Center for International Studies, Room 539, Maginnes Hall. The Study Abroad Coordinator maintains a list of approved programs and can advise students on all aspects of study abroad. In addition, the Study Abroad Coordinator refers students to faculty members and other university personnel who can be helpful to students in making study abroad decisions. Students considering study abroad are encouraged to make an appointment with the Study Abroad Coordinator at the end of their freshman year or early in their sophomore year to allow adequate planning time.

Students interested in study abroad during the semester or year should have a minimum grade point average of 2.7 and should be in good standing. A student with an average below 2.7 may petition the Committee on Study Abroad for approval to study abroad.

Students intending to receive academic credit for a study abroad program at Lehigh University must submit a Lehigh study abroad application to the Center for International Studies and complete other procedures established by the Committee on Study Abroad. Applications to the Center are due mid-January to early February for fall programs and October 1 for spring programs (See the deadline for summer programs in the section below). Applicants are required to consult with academic advisers, get courses approved by departments, and—for agreement programs or petitions—request recommendations by faculty.

All students who study abroad for a semester or year pay a program fee to Lehigh University to cover tuition and other costs. Students on financial aid continue to receive financial aid while participating in a semester or year abroad.

Lehigh students are encouraged to develop skills in a foreign language sufficient for study abroad in that language. Most programs in non-English speaking areas require four or five college semesters of language study. The Department of Modern Foreign Languages and Literature offers merit scholarships of limited amounts to assist with travel costs for foreign-language study programs. Applications and information about the scholarships are available through the MFL department.

Students may receive academic credit with grades for inter-institutional agreement programs that have been endorsed by Lehigh's faculty (see below). On other programs students get full credit for grades of C or higher but do not receive grades recorded on the Lehigh transcript or figured into the cumulative average.

Lehigh University currently has formal agreements with universities in the United Kingdom and with two institutions in France. Students selected through faculty interviews for these programs can study for a year at the University of Edinburgh, the University of Kent, London School of Economics and Political Science, the University of Manchester Institute of Science and Technology, or the Université Paul Valéry in Montpellier, France. Students can study for a semester at the University of Buckingham or for a semester or year at the University College of London, the University of York, or the Ecole Supérieure de Commerce et d'Administration des Entreprises de Poitiers—a business school in France.

Lehigh has student exchanges with four of the above institutions: Kent, Paul Valery, the Ecole Supérieure (Sup de Co), and Buckingham. Students may also go on exchange to Russia and other republics of the former Soviet Union through Lehigh's membership in the American Collegiate Consortium for East-West Cultural and Academic Exchange.

Architecture and Urban Studies students who qualify can earn credits with grades on the Columbia University program, "The Shape of Two Cities: New York and Paris," which offers a semester of study in each location.

Summer Programs

Lehigh University offers its own summer study programs in Europe through the Office of Continuing Education and Summer Sessions. Typically, students take two five- or six-week courses taught in English by Lehigh University professors. These study abroad opportunities are available to all students in good academic standing with the exception of the internship program in London, which requires a 2.7 GPA.

As a member of the Lehigh Valley Association of Independent Colleges (LVAIC), Lehigh University sponsors three six-week summer language programs in Europe: Poitiers, France; Bonn, Germany; and Seville, Spain. The six credits earned are automatically transferable to Lehigh University and will be counted as part of the student's cumulative grade-point average.

The Lehigh Valley Center for Jewish Studies sponsors summer, semester and year study programs in Israel in cooperation with Tel Aviv University and Hebrew University in Jerusalem. During the summer, students may also participate in the Tel Mique-Ekron Archaeological Excavations as well as a kibbutz study program. Limited scholarships are available from the Lehigh Valley Center for Jewish Studies for qualified students on a competitive basis.

Students who wish to go on summer programs other than those sponsored by Lehigh should apply to the Center for International Studies by April 1. The Study Abroad Coordinator advises students on procedures for approval of non-Lehigh summer programs and credit.

Experiential Learning

The accommodation of student interest extends beyond regular departmental offerings. Hands-on experiences in learning enrich classroom instruction. Each of the three colleges offers a number of such experiences to undergraduates. Among them:

The Philadelphia Urban Semester. Undergraduates in all fields of study can earn 16 Lehigh credit hours by spending a semester studying in the nation's fourth-largest metropolis. They live, work, and study with other students from two dozen other institutions, supervised by faculty of the Great Lakes Colleges Association. This consortium of such leading Midwestern institutions as DePauw, Kenyon, Oberlin, and Wooster is a recognized leader in providing extra-mural academic programs both here and abroad.

The curriculum consists of two four-credit seminars and an eight-credit internship. All students are enrolled in a core "Seminar on the City" which introduces them to the field of urban affairs and to Philadelphia. The second seminar is elected from a half-dozen more specialized urban topics; recent choices available have included "Folklore in Philadelphia," "Art in the City" (which met each week at a different site), and "Justice." Internships involve working four days weekly in a public or private placement which tests the student's aptitude in a variety of practical ways while enhancing appreciation of city life.

The Washington Semester. Opportunity is available each year for six juniors or seniors to spend a term studying in Washington, D.C., in cooperation with American University. Lehigh University is a member with 180 other colleges and universities.

Students enroll at Lehigh but spend the semester in residence at American University with the students from other participating colleges.

The curriculum consists of national-government seminars, an internship, and a written research project.

Besides the national government program, the student may choose other program offerings such as economic policy semester, journalism, public administration, foreign policy semester and justice semester.

Inspection trips. The location of the university in the center of industrial activities of various types affords unusual opportunities for visits to manufacturing plants. Inspection trips to individual plants are a required part of specific courses in various engineering curricula. Written reports may be required. These trips are generally held during the senior year and involve an average expense of \$25 to \$50.

Credit by Examination

Upon petition and presentation of evidence that he or she has qualified for it, a student already enrolled at Lehigh may be permitted by the Standing of Students Committee to take a special examination for credit towards graduation. Special Examinations are granted only for extraordinary reasons and upon petition. There must be adequate supporting evidence of sufficient cause accompanying each petition. There is a fee for all special examinations.

Students taking a special exam after matriculation at Lehigh will have the grade and credits assigned to their permanent Lehigh record. Special exam credit will be counted as in residence credit and the grade will be used in all grade point average calculations. No special exam will be granted in a course that the student has already taken (except Senior reexaminations), or in a course in which the student has already completed more advanced work at Lehigh.

Preparation for Graduate Work

Students planning to continue in graduate programs should take advantage of the flexibility in many undergraduate programs to design an upper-division curriculum that meets requirements in the anticipated graduate program.

The policy of the Graduate School provides as much flexibility as possible for students who wish to change to new but related fields of study after the baccalaureate degree. Students should consult with their previous program adviser and the department representative of the new field to establish an academic program that will remedy any deficiencies in background.

Apprentice Teaching

The apprentice teaching program is designed to benefit juniors and seniors who wish to learn about teaching under the guidance of an experienced teacher. Apprentices often do a limited amount of supervised lecturing or leading of discussions, assist in making up and evaluating written assignments, and are available for individual consultation with students.

To participate in the apprentice teaching program a student must:

1. Have an over-all cumulative grade point average of 2.80 or better;
2. Have a cumulative grade point average of at least 3.3 and have completed at least two courses in the major field in which apprentice teaching is done and;
3. Have previously taken for credit the course or its equivalent in which the apprentice teaching will be done.

A student may register for apprentice teaching only once each semester, only once in a given course, and only twice during a college career.

To register for apprentice teaching each student-teacher partnership will submit an apprentice teaching agreement, indicating the duties and obligations for approval to the department chair and the dean of the student's college in which the course is taken. This form must be submitted to the Registrar before the first day of classes in the semester. To complete the course, the apprentice teachers must submit a written report of their experience to the supervising teacher, who will forward it to the Office of the Provost.

Curricular Flexibility

Choice is a regular part of university life, and encompasses the determination of a college and major, the selection of courses each term, and the development of life goals and career options.

Many of these choices are academic in nature. The undergraduate curricula are flexible, designed to accommodate the changing interests and needs of students. Boundaries between colleges are as fluid as possible to provide many options in an educational program. For instance, students may take a bachelor of science (B.S.) degree in the College of Business and Economics or the College of Engineering and Applied Science with a minor in journalism in the College of Arts and Science. There are five-year programs for which degrees are awarded in two colleges.

Transfers between undergraduate colleges is permitted but only *after the freshman year*. Students considering such a transfer must confer with their advisers to begin the process.

Academic offerings of the various departments are described in Section V. To provide additional flexibility and encourage student initiative and depth of investigation, the university has developed academic alternatives including the following:

Provisional Courses. Departments may introduce Provisional Courses temporarily within a semester, either experimentally or as a response to a contemporary social or scientific issue. If successful, a course may become part of the regular curriculum. Such courses, identified with a 95, 96, 97 or 98 number (preceded by a 1, 2, or 3 indicating level) may sometimes be taken on a pass/fail basis.

Independent Study. Juniors and seniors of ability who wish to concentrate in their chosen field can substitute no more than four or six credit hours of independent, unscheduled work each semester for an equal number of credit hours of elective work required for graduation. Students, in collaboration with the major adviser, with the advice of the departmental chairperson and consent of the college dean, may structure such a project for study in any curriculum and most major study sequences.

Pass/Fail Option. Students have the opportunity to study in areas without concern for possible poor grades by electing a pass/fail option. Intended to encourage exploration at the upper division level outside the major field, this option is open to those who are sophomores and above, in good standing, who have declared a major. The pass/fail option may not be used for major or minor subject credit toward graduation or for distribution requirements. Consultation with the adviser is required.

Graduate Courses. Qualified undergraduates may petition the Graduate Committee to register for 400-level courses if they are certified by the course instructor and the department chairperson concerned.

LVAIC Cross Registration

Currently enrolled full time degree seeking students in good academic standing who have achieved sophomore status may register for up to two courses per term that cannot be scheduled at the home institution at any one of the member institutions (Allentown College of St. Francis de Sales, Cedar Crest College, Lafayette College, Moravian College, and Muhlenberg College). The student must obtain the appropriate approvals of his or her own adviser and the host institution registrar. The courses must be in the normal academic load and not produce an overload.

All grades of courses taken through the LVAIC cross registration process will be accepted by the home institution and entered on the permanent record, and such grades will be used in computing the grade point average. Credits taken through the cross-registration process will be calculated as in residence. The number of credit hours assigned to a course is the responsibility of the home institution Registrar.

Students may not repeat a course at another LVAIC institution in which they expect to have a Lehigh cumulative grade point average adjustment.

Lehigh University students are not permitted to cross

register for courses in ALL JANUARY INTERSESSION PROGRAMS, the EVENING PROGRAM AT MUHLENBERG COLLEGE, all WEEKEND COURSES AT CEDAR CREST COLLEGE, or the ACCESS PROGRAM AT ALLENTOWN COLLEGE. All independent study and correspondence courses are prohibited from cross registration without prior approval of the Lehigh University Standing of Students Committee.

SUMMER SESSION—Lehigh Students must have been registered full time in the prior Spring semester to be eligible to cross register for a summer term. A maximum of two courses per session, and 12 credit hours over the course of the entire summer may be rostered. Students may not cross-register for a course being offered at Lehigh during the same Summer term.

The General College Division

The General College Division supplements the mission of the established undergraduate curricula by providing: an opportunity for persons not planning to qualify for a degree to pursue work, either of a general or specialized nature, which their preparation and interests make desirable; a trial period for those who wish to become candidates for baccalaureate or graduate degrees, but whose preparation does not satisfy the entrance requirements for the established curricula; and an opportunity for qualified students to continue their education without being committed to a restricted or specialized program of studies. Courses taken in the General College Division may not be submitted to meet the requirements for a graduate degree.

For admission to the General College Division the student must submit an application to the undergraduate admissions office. The applicant must show maturity, seriousness of purpose, and evidence of ability to pursue with profit the program of studies he or she desires. The student must have the established prerequisites for courses in which he or she wishes to enroll, and may register for courses up to and including the 300-level.

There is no established curriculum for the General College Division. Each student works on a program outlined to meet his or her special needs. Each program must be approved by the Registrar, director of the division. Students in the division are not permitted to take courses using their optional Pass/Fail grading system, or cross register for courses in the L.V.A.I.C.

Students in the division are not candidates for degrees. A student may transfer to regular matriculated undergraduate status in any of the colleges only upon petition to, and with the approval of, the committee on standing of students. Transfer to the graduate school is possible only through the normal graduate admission process.

Transfers from regularly matriculated status in any of the colleges to the General College Division may be made only with the approval of the committee on standing of students. Transfers from the Graduate School require the approval of the graduate committee.

With the exception above, students in the General College Division are subject to the same rules and regulations as students of the university. They pay the tuition and fees established for regularly matriculated students.

Continuing, Distance and Summer Studies

Continuing Education:

Lehigh University departments, research centers, and administrative agencies offer a varied selection of non-credit continuing education programs for adults. Reflecting Lehigh's traditional educational strengths, these offerings focus on professional development, organizational problem solving, and technical skills. These programs carry no

regular academic credit, but participants can earn Continuing Education Units (CEUs). In awarding CEUs, Lehigh follows the guidelines developed by the National Council on the Continuing Education Unit.

Lehigh continuing education programs are often designed to meet specific needs. Contents, schedules, and timing are adapted to effectively serve the audiences for which they have been developed. Apart from public programs presented on the Lehigh campus, a number of programs are available for "in-house" presentation to organizations on a contract basis.

Distance Education:

The University operates its own Ku-Band satellite earth station, and transmits both credit and non-credit programming. On the credit side, Lehigh offers a full Master's Degree program in Chemistry by satellite, and

provides courses for the National Technological University's Master's Degree program in Management of Technology. Non-credit distance learning programs include short courses and seminars of interest to professionals in industry and education.

Summer Studies:

There has been a summer session program at Lehigh University for nearly a century. Presently offering more than 200 credit courses on campus, this program serves Lehigh's regular graduate and undergraduate population, area teachers and other professionals, and students from other institutions of higher learning who return to their homes in the Lehigh Valley during the summer. At Lehigh, the summer is a time in which experimentation is encouraged. The result is innovative courses and programs which are often unavailable at other times of the year.

IV.



Graduate Study and Research

The Graduate School

Lehigh began awarding graduate degrees in 1882. The first recipient, T.H. Hardcastle, of the Class of 1880, wrote his thesis on Alexander Pope, entitled it *The Rights of Man*, and read it aloud at commencement in June 1882.

The first Ph.D. was granted in 1895 to Joseph W. Richards, Class of 1886. Richards, who had a background in metallurgy and electrochemistry, taught at Lehigh until his death in 1921.

Women were admitted to the graduate program in 1918 when the faculty and the board of trustees agreed to grant the degrees of M.A. and M.S. to women, provided they attended classes in the late afternoon and on Saturdays "so that the general character of campus life shall not be affected." Three women received graduate degrees in 1921, the first women to complete graduate work at Lehigh. In 1929, the rule was changed, and women were admitted on much the same basis as men.

In 1936, the Graduate School was established to administer the graduate program. The Ph.D., which was temporarily discontinued in 1894, was reinstated in nine departments: chemistry, chemical engineering, civil engineering, geology, history, mathematics, mechanical engineering, metallurgical engineering, and physics. Tomlinson Fort, professor of mathematics, was selected in 1938 as the first dean of the Graduate School.

In 1961, the university officially resolved to strengthen and expand graduate programs university-wide. Since then, graduate work has assumed increased importance and prominence, and facilities and funding have increased tremendously.

College of Arts and Science

James D. Gunton, dean

Within the College of Arts and Science, professionally oriented students may pursue advanced degrees in chemistry (M.S., Ph.D., D.A.), English (M.A., Ph.D.), geological sciences (M.S., Ph.D.), government (M.A.), history (M.A., Ph.D.), mathematics (M.S., Ph.D.), physics (M.S., Ph.D.), psychology (M.S., Ph.D.), social relations (M.A.), and applied social research (Ph.D.).

Although degree requirements vary from department to department, most departments require a combination of formal coursework and independent research. Students work closely with a faculty adviser both in formulating and carrying out their research programs. Given the nature of the liberal arts, these programs commonly involve faculty and/or coursework from more than one department or a department and research center/institute. Students interested in such an interdisciplinary approach are admitted to a single department but formulate a program of study and research that draws on faculty and facilities in other areas of the university. Superior candidates may qualify for financial support in the form of teaching

assistantships, graduate assistantships, research assistantships, scholarships, or university fellowships.

College of Business and Economics

James W. Schmotter, dean

The College of Business and Economics offers the master of science degree in economics, master of business administration, master of management science, master of science in management of technology and the doctor of philosophy degree in business and economics.

Graduate education in the College of Business and Economics distinguishes by emphasis between professional management training through the M.B.A., which generally, though not always, concludes at the master's level, and graduate pursuit of business and economics subjects in depth for research and/or teaching expertise through the doctoral and related M.S. programs.

There are six departments in the college: accounting, economics, finance, law and business, management, and marketing. Course descriptions can be found listed under these departments in Section V; more information about the various degree programs appears below. The college publishes a brochure describing its graduate programs, which may be obtained by writing to the Graduate School, College of Business, Rauch Center, 621 Taylor Street, Bethlehem, Pa. 18015.

College of Education

Alden J. Moe, dean

The College of Education offers the master of arts in education, the master of education, the master of science in education, the educational specialist, the doctor of education, and the doctor of philosophy. More information about these degrees appears below.

The College was established as the School of Education in 1966, elevating it from its former departmental status under the College of Arts and Science. In 1985 the school was given its present status as a college, headed by a dean. The College is engaged in the preparation of elementary and secondary teachers in both school and nonschool settings, school and community counselors, counseling psychologists, school psychologists, school administrators, reading specialists and supervisors, curriculum specialists and supervisors, specialists and supervisors in the education of mentally and emotionally disturbed children, teachers of preschool children (especially children with handicaps), teachers for the social restoration of potential delinquents, and specialists in educational technology.

The College of Education is interested in potential and established leaders in all aspects of educational endeavor. A total of 540 students are involved in advanced study at the master's and doctoral levels during the 1992-93 academic year.

Through its working relationship with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergraduate preparation

programs by emphasizing study at the graduate level. Off-campus course work and in-service projects are integral parts of many programs.

An intern teaching program is specifically designed for qualified persons who hold bachelor of arts degrees and who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as interns in the public schools. After two semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, these students ordinarily will have completed requirements for the M.A. (secondary teachers) or the M.Ed. (elementary teachers), as well as state certification.

Organization. The College of Education is organized into two departments and eight program areas. The departments are the Department of Counseling Psychology, School Psychology, and Special Education, and the Department of Leadership, Instruction, and Technology. The eight program areas, each having its own coordinator, are educational leadership, counseling, educational technology, reading, school psychology, social restoration, special education, and teacher education.

Centennial School. The College of Education operates the Centennial School—a laboratory facility for exceptional children that has both an elementary and a secondary component. Centennial School provides research opportunities as well as practical experience for advanced students in counseling, school psychology, special education, and reading.

Undergraduate minor in education. Upper-level undergraduates are given an opportunity to take a minor in education that combines practicum activities with theoretical work and is designed to provide a foundation for further educational studies at the graduate level.

College of Engineering and Applied Science

Sunder H. Advani, dean

The College of Engineering and Applied Science offers the master of science, master of engineering, and doctor of philosophy degrees in each of its six academic departments and in interdisciplinary programs as well. Each department creates its own course, examination, and thesis or dissertation requirements within the framework of those established by the Graduate School. The departments in the college offering graduate degrees are chemical engineering, civil engineering, electrical engineering and computer science, industrial engineering, mechanical engineering and mechanics, and materials science and engineering.

Graduate study in the College of Engineering and Applied Science is closely related to the college's extensive research activity, and all graduate students are expected to engage in analytical or experimental research as part of their programs of study. This activity involves students in the process of creation of new knowledge under the direction of the college's distinguished faculty and brings them into contact with some of the most modern and advanced experimental techniques. Many college research programs are supported by contracts, fellowships, and grants from industry and from federal, state, and local governments. This funding not only provides financial support for outstanding students but also allows them to deal with some of the more complex and pressing problems facing our society now and in the 21st century.

Many faculty members and graduate students in the College of Engineering and Applied Science are associated with interdisciplinary research centers and institutes as well as with their own departments. This opportunity for interdisciplinary study allows them to cross departmental lines in specific technological areas and to work with faculty and graduate students from other departments. Centers and institutes currently carry on research in the areas of biotechnology, health sciences, thermofluids, materials, energy, environmental sciences, surfaces and coatings,

solid-state studies, structural and geotechnical studies, high-rise habitats, emulsion polymers, fracture and solid mechanics, metal forming, robotics, computer-integrated manufacturing, and design and management innovation. Extensive research in many of these areas is also conducted with academic departments. All students in interdisciplinary degree programs are associated with specific academic departments.

Admission to Graduate Study

A graduate of an accredited college or university may be considered for admission to the Graduate School. The decision to admit a student ordinarily rests with the applicant's major department and stands for one year following the first semester for which admission was offered. If more than one year elapses, the prospective student's department reserves the right to reconsider the original offer.

Applications for admission may be obtained by writing to the Graduate Admissions Office, 5 E. Packer Avenue, Lehigh University, Bethlehem, Pa. 18015.

An applicant may enter the graduate program as a student in one of two categories: regular or associate. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate admissions office either as regular or associate graduate students may register for graduate courses or take them for credit.

Regular graduate students. Only regular graduate students are candidates for graduate degrees. Application for admission as a regular graduate student must be filed by July 15 for the following fall semester or by Dec. 1 for the spring semester. Regular applications for the first and second summer sessions are accepted until April 30 and May 30 respectively. In order to be considered for admission as a regular graduate student, the applicant must satisfy at least one of the following conditions: have an undergraduate G.P.A. of at least 2.75 out of 4.00; have an average of at least 3.00 for the last two semesters of undergraduate study; have scores at or above the 75th percentile on the Graduate Record Examination or other recognized test (all foreign graduate students are required to take the Test of English as a Foreign Language and achieve a minimum score of 550); have a graduate grade-point average of at least 3.00 for a minimum of twelve credit hours of graduate work completed at other institutions; or have successfully satisfied the probationary conditions as an associate graduate student discussed below. Satisfying one of these conditions is a necessary but not sufficient condition for admission as a regular graduate student.

Individual departments may evaluate their candidates for admission according to higher standards and additional criteria. Departments should be consulted for information regarding required examinations for admission. For example, candidates for the M.B.A. program are required to take the Graduate Management Admission Test (GMAT).

Admission of a student to graduate standing is executed through the Office of Graduate Admissions. Credentials for admission to all Counseling Psychology and School Psychology Programs and to the Doctoral Programs in Special Education are acted upon only once a year. Completed applications and requests for financial aid must be submitted by February 1 for admission in the following Fall semester. Applications received for these programs after this deadline will be dealt with on a space available basis.

Associate graduate students. Associate graduate student status may be offered to applicants who apply but fail to qualify for regular graduate student status. Only associate student applications will be considered during the late admissions period between the end of the regular admission period and the first day of classes. Applicants for associate status may submit unofficial rather than official transcripts; letters of recommendation are not required at that time. The Registrar will require an official final transcript, however, before grades are released.

Associate graduate students who are admitted during the late admission period and who clearly qualify for admission as regular graduate students may petition for regular status

after classes begin if all credentials are in order. There is no late application fee.

Other associate graduate students must meet the following condition before they may petition for regular status: completion of the first nine credit hours of courses numbered 300 or higher with at most one grade of C, C+, or B-; all other grades must be B or better. Students receiving a grade of C- or lower will be dropped from the program. Students should note that individual departments may impose more rigorous probationary standards.

When the probationary period of nine credit hours is completed successfully, associate graduate students must petition for regular student status in order to continue. This requires the submission of regular admission documents not already on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

Lehigh University undergraduates. A Lehigh undergraduate may take any 400-level course for which he or she is qualified. The qualifications are defined by the department, and are certified by the course instructor and department chairperson through petition to the graduate committee.

Undergraduates at Lehigh who are within a few hours of meeting the requirements for a baccalaureate degree may, with the special approval of the graduate committee, enroll for a limited amount of study for graduate credit. Lehigh undergraduates may apply course credits taken in the undergraduate program toward a graduate degree under the following conditions: (a) the course credits are not submitted as part of the requirement for an undergraduate degree; and (b) courses for possible graduate credit are approved in advance by the course instructor, department chairperson, and the dean of graduate studies. The student must receive a grade of B- or better.

Readmission. A student who has not been registered in a Lehigh graduate program for five years must petition for readmission. Petitions approved by the student's major department must be forwarded to the graduate admissions office.

International Students and Scholars. International applicants must hold an American Bachelor's degree or an equivalent foreign degree requiring at least 16 years of primary, secondary, and university education. International applicants must submit all documents required for regular graduate student status, as explained above. Brochures for international applicants may be requested from individual departments. For additional information, please refer to page 20 of the catalog.

Registration

Requirements. All graduate students using Lehigh University resources must be registered. No graduate student may register for more than 15 credits per semester. University employees may register for, at most, two courses per semester with appropriate approval. The maximum registration in a summer session is six credits.

Full-time status. In order to maintain full-time enrollment status, a graduate student must ordinarily register for a minimum of nine credits each semester. Identification as a full-time student is important for three purposes: (1) eligibility for financial aid, (2) compliance with visa requirements for international students, and (3) for university and national graduate enrollment data.

After fulfillment of degree credit-hour requirements and in some other circumstances, full-time status may be maintained with fewer than nine credits of registration, provided that the student is, in fact, continuing a program of full-time study and research. In such cases, the status must be certified on the Graduate Registration form, first by the department and then by the Dean of Graduate Studies.

Registration procedure. Graduate registration is held during the week preceding the start of classes. Students should check with their departments for registration and semester class schedules. To register, graduate students must complete registration forms available in their departments. A course adviser will discuss course selections with students and sign registration forms upon approval.

Late registration penalties. Registration between the second and tenth day of class during the fall and spring semesters, and the second and fifth day of class during the summer sessions will require a late registration fee. Students who have not completed the registration process by the tenth day of the regular academic semester or by the fifth day of the summer session will not be permitted to attend class.

Services provided by the registrar. In addition to maintaining student academic files, the office of the registrar fills transcript orders. The registrar honors written and over-the-counter requests to have transcripts mailed to schools and prospective employers.

The office also forwards final grades to students approximately two weeks after each final exam period, provided student credentials are in order.

Graduate Credit and Grades

Course grades are defined as for undergraduates except that no grade lower than C- may be counted toward a graduate degree and pass-fail registration is not allowed for graduate students. No student who receives more than four grades below a B- in courses numbered 200 or higher is allowed to continue registration as a graduate student.

The N grade is defined as for undergraduates except that graduate students have a calendar year to remove course incomplete grades unless an earlier deadline is specified by the instructor. Graduate student incomplete course grades that are not removed remain as N grades on the student's record. Thesis or research project N grades may remain beyond one year until the work is completed.

The X grade is defined as for undergraduates except that to be eligible for a make-up examination a graduate student must file a petition and the petition must be approved by the graduate and research committee.

The XN grade is defined as for undergraduates except that graduate students have a calendar year to complete coursework following an XN grade unless an earlier completion deadline is specified by the instructor. The X portion of the grade is removed as described for undergraduates. XN grades which are not removed remain on the record of graduate students. All petitions for exceptions are sent to the graduate committee.

A withdrawal from a course within the first ten days of classes is not recorded on the student's record.

A student who wishes to withdraw from a course after the tenth day, but not after the ninth week of instruction, receives a grade of W. A student who withdraws after the ninth week period will receive a WF or WP at the discretion of the instructor.

A student withdrawing from the University (dropping all classes) after classes begin through the end of the ninth week of instruction will have all courses assigned a "w" notation and have the date noted on the students academic transcript.

A student withdrawing from a course submits a department approved change of roster form to the Registrar's office.

Graduation

Degree registration. A student must be registered in the semester in which the degree is conferred. A spring or summer registration will satisfy the registration requirement for the following Founder's Day degree, provided all work is completed before the first day of fall classes.

Application for degree. Candidates for degrees to be conferred on University Day in May or June must file an application for degree with the registrar by March 1. Candidates for degrees to be conferred on Founder's Day in October must file this form by September 1. Candidates for degrees to be conferred in January must file by December 1. Late application for a degree will incur a penalty fee of \$25.

Clearance. Graduate students must receive clearance from the university prior to the awarding of the degree. The following obligations must be satisfied:

- Students must be certain that they have completed all

coursework for incompletes they may have received.

- Theses and dissertations must be cleared by the Graduate School office.
- All financial obligations must be cleared with the bursar. Tuition fees, bookstore charges, library fines, and motor vehicle fines must be paid before graduation.
- All library books on loan must be returned.
- Students must turn in their student identification cards at Christmas-Saucon Hall Annex.
- The interdepartmental clearance sheet must be completed. This form requires the signature of the student's department chairperson (except for the College of Education), and the facilities services office before it is submitted to the registrar at least three days prior to graduation.

Tuition

Tuition payment. Graduate students must register for courses and pay tuition bills at the bursar's office during the registration period held the week before classes begin.

Students who mail their registration forms, personal data sheets, and tuition payments to the bursar's office must be certain that their forms are postmarked two business days prior to the final day of the registration period.

Tuition refunds. A student in good standing who formally withdraws from a course during the first eight weeks of the semester is eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to the start of the semester	100%
during first calendar week	80%
during second calendar week	70%
during third calendar week	60%
during fourth calendar week	50%
during fifth calendar week	40%
during sixth calendar week	30%
during seventh calendar week	20%
during eighth calendar week	10%

Students should note that the first calendar week begins with the first day of classes at the university.

Tuition and Fees for 1993-94

	per credit hour	per semester
Tuition	\$670	
Per course charge for audit	670	
Tuition for enrollees in the College of Education and for full-time elementary and secondary teachers and administrators enrolled in the other three colleges	390	
Maintenance of candidacy		670
Master's candidate registration fee		670

Living accommodations. The university maintains a graduate student housing complex in the Saucon Valley that has 112 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 1993-94 period beginning in September, the following monthly rents exclusive of utilities prevail:

Efficiency apartment	\$360
One-bedroom apartment	425
Small two-bedroom apartment	465
Two-bedroom apartment	480
Three-bedroom apartment	490

Other Fees

Application fee (for graduate admission consideration)	\$40
Graduate activities fee, per semester	
Full-time students	12
Part-time students	6
Late registration (for completing registration after announced day)	50
Late application for degree	25
Late payment (after announced date)	50
Return check fine	20
Identification card (replacement)	10
Thesis, microfilming	25
Dissertation, microfilming	50
Placement fee, College of Education	25
Supervision fee, College of Education (per 3 credits)	
Counselor intern	100
Counselor and school psychology clinic	100
Social restoration intern	225
Reading practicum	100
Administrative intern	225
Elementary and secondary intern	225
Special education intern	225

Financial Aid

Financial aid is ordinarily available only for regular, full-time graduate students. Teaching assistantships, research assistantships, graduate assistantships, fellowships, and scholarships are academic awards made by individual academic departments or by the Graduate School. Several graduate assistantships unrelated to a particular area of study can be obtained by applying to administrative offices. Finally, loans and work-study employment are distributed by the Office of Financial Aid. International students are also encouraged to apply for funding to outside sponsoring agencies and/or home governments.

Academic awards. Requests for fellowships, scholarships, research assistantships, teaching assistantships, and graduate assistantships to begin in the fall semester must be filed with academic departments no later than January 15. Generally, a special committee formed by department faculty selects the recipients of these awards based upon merit; students are not required to submit a financial statement.

In addition to their stipends, graduate students holding half-time teaching appointments generally receive tuition remission. Fellowship holders also receive a stipend and tuition award. Scholarship recipients are awarded tuition. Research assistants receive a stipend for research services, but their tuition is commonly paid directly by research projects.

Teaching assistants and graduate assistants. Teaching assistant and graduate assistant (TA/GA) are technical terms used to describe specific types of Lehigh University student employees. The duties of TAs and GAs are generally set by the departments or offices that employ them, but certain conditions must be satisfied before a student can be classified as a teaching assistant or a graduate assistant. These include:

- Each TA/GA must be a regular full-time resident Lehigh graduate student, which normally requires registration for at least nine credit hours per semester.
- A TA/GA is a half-time position and each TA/GA provides services to Lehigh University of up to twenty hours per week. Quarter-time and eighth-time TA/GA appointments are possible for full-time resident graduate students, with stipends and tuition remission appropriately reduced.
- Each TA/GA must be paid a specific stipend, which is set for the academic year by the dean of graduate studies after consultation with the director of budget.
- Qualified TAs/GAs receive tuition remission for at most ten credit hours in a regular semester. No TA/GA may register for more than ten credit hours. A student who is a TA/GA during the preceding academic year is entitled to at most three hours of thesis, research, or dissertation registration (not course credit) in the following summer without payment of tuition.

- Each TA/GA is appointed by a process which begins with a formal letter of appointment issued by the appropriate department chairperson. The appointment letter specifies standard university conditions including stipend level, time of arrival, length of service, and the requirement of satisfactory academic progress and performance of duties. Each department chairperson submits written notification of TA/GA appointments to the appropriate college dean or vice president.

The graduate committee endorsed academic guidelines for new teaching assistants which exceed minimum admission requirements. Each TA should satisfy one of the following: have a G.P.A. of 3.0 or better in the undergraduate major field of study; have a G.P.A. of 3.5 in the senior year major field; rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test; or have a G.P.A. of 3.5 in at least twelve hours of graduate work in the major field. Exceptions to these guidelines shall be made only with the approval of the dean of graduate studies.

In addition, each teaching assistant must make normal progress toward a graduate degree. The definition of normal progress may vary among departments, but the criteria for satisfactory progress are established by the department faculty and the graduate committee. Teaching assistants who fail to satisfy these criteria are ineligible for reappointment.

Teaching assistants whose native language is other than English must have on record with the ESL Program in addition to a minimum total score of 550, a comprehensibility score of 230 or higher on the SPEAK (Speaking Proficiency English Assessment Kit) or the TSE (Test of Spoken English) in order to work with Lehigh undergraduates in academic settings (i.e., classrooms, recitations, labs, office hours, etc.).

Those whose comprehensibility score is 220-229 may also be appointed as TAs, but they are required to attend ESL courses until their comprehensibility score is at least 230 or until they no longer have a TA position. A comprehensibility score of 200 or below eliminates an international graduate student from being appointed as a TA.

The SPEAK is given at announced times during the academic year, usually at the beginning and end of each semester. Contact the ESL Program (302 Coppee Hall, ex. 86099) for details and for information concerning ESL courses. The TSE is given by ETS several times each year throughout the world.

- Tuition remission for qualified TAs/GAs is authorized by the appropriate dean or vice president as part of the registration process.

- Each college dean or appropriate vice president will be provided tuition remission accounts against which TA/GA remissions will be charged. The accounts will be budgeted at an amount equal to the ten-hour TA/GA tuition rate times the approved number of TA/GA positions included in the annual operating budget. The budgets shall not be exceeded. If additional TA/GA positions are desired on a temporary basis, the account executive must provide for the transfer of budget support to the remission account. These budgets are to be used exclusively for tuition remission for authorized TA/GA positions.

There are a limited number of summer TA/GA appointments. These TA/GA employees must receive the same monthly stipend as academic year TAs/GAs and provide services of up to twenty hours per week to the university. A summer TA/GA registers for a maximum of three credit hours in each summer session of employment and receives tuition remission for that registration.

Other graduate assistantships. Graduate students may apply directly to administrative offices for graduate assistantships unrelated to their areas of study. The availability of these assistantships is based upon the needs of the individual departments. GAs are employed regularly by the graduate school office, the office of the vice president of student affairs, the dean of students office, the university counseling service, and by career services.

Loans and work-study awards. Student may apply for the federally-funded Stafford and Perkins loans, Lehigh University Tuition Loans (UTL), and Federal Work-Study through the Office of Financial Aid at 218 W. Packer

Avenue. These funds are awarded on the basis of demonstrated need using the *Free Application for Federal Student Aid* and a university application. (Programs available, without regard to "need," are the Federal Unsubsidized Stafford Loan and the Supplemental Loan for Students (SLS).) Also required in the application process is a Financial Aid Transcript from any (and all) post-secondary schools attended whether or not you received aid. Funds cannot be disbursed without a FAT on file. This is a federal requirement.

Literature on federal student aid programs are available through the financial aid office. Particulars on the Federal Stafford Loan (with and without subsidy) and the Supplemental Loan for Students (SLS) are also available at participating lenders.

Degree Information

The following degrees are offered by the Graduate School: the master's degree, the doctor of philosophy, and the doctor of arts.

Master's Degree

Candidates for the master's degree have six years in which to complete their programs. Students should confer with their advisers to be certain that specific department and program course requirements are met. The following requirements must be satisfied by master's candidates in all departments.

Program for the master's degree. A student's program must include: not less than 30 credit hours of graduate work; not less than 18 credits of 400-level coursework (research or thesis registration counts as part of the 400-level coursework requirement); not less than 18 credits of coursework in the major of which 15 credits must be at the 400 level. All coursework for the master's degree must be taken under at least two instructors and must normally be done in attendance at Lehigh University. With the approval of the dean of graduate studies, a maximum of six credits may be transferred to a Lehigh Master's program. A petition is submitted, with course descriptions and transcript, as well as departmental recommendation. Course grades of B or better are required.

A student must complete the form, "Program for Master's Degree," setting forth the courses proposed to satisfy the degree requirements. This form should be approved by the department and then submitted to the Graduate School as soon as possible after 15 credit hours toward the degree have been completed. Approval of the program by the Graduate School signifies that the student has formally been admitted to candidacy for the master's degree.

Thesis and comprehensive exam. Candidates are required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements applies and may require both. If required, the thesis or report shall not count for more than six credit hours, and thesis registration is limited to a maximum of six credit hours. University procedures must be followed if the thesis or research project involves human subjects. One unbound copy of the thesis, approved by the thesis adviser and the department, must be delivered to the Graduate School at least three weeks before the degree is conferred. A binding and microfilming fee of \$25 must be paid to the bursar, and the bursar's receipt presented with the completed thesis. Guidelines stipulating the form of the thesis are available in the Graduate School office.

A **non-thesis option** exists in certain departments in the College of Engineering. Students should check with their departments regarding that option.

Doctor of Philosophy

Time and Registration requirements. A candidate for the doctor of philosophy degree is expected to devote at least three academic years to graduate work. All post-baccalaureate work toward the doctorate must be completed within ten years. A student beginning doctoral coursework after an elapsed period of at least one semester after the

master's degree has been conferred is granted seven years in which to complete the doctoral program.

Doctoral students whose graduate study is carried out entirely at Lehigh University must register for a minimum of 72 credits beyond the Bachelor's degree. However, resident students who during their entire doctoral program, including the semester of graduation, have paid full tuition continuously (normally a minimum of 9 credits per academic semester) will have satisfied the tuition requirements for the doctoral degree upon completion of all other requirements. Students who have earned a Master's degree at another university must register for a minimum of 48 credits. These requirements include registration for research or dissertation credits.

Full-time students working toward the doctorate normally register for a minimum of nine credits each semester. If the minimum degree registration requirement of 72 or 48 credits is attained prior to formal admission to doctoral candidacy, continued registration of at least three credits per semester is necessary. Full-time student status must be certified on the graduate registration form.

After admission to doctoral candidacy, a student must maintain candidacy by registering at least two times each calendar year (in each academic semester or in one academic semester and one summer session). After completion of the minimum registration requirement plus any additional requirements of the student's department or program, registration is permitted for 'Maintenance of Candidacy.' The tuition charge is for one credit-hour. Full-time status again must be certified on the graduate registration form.

Residence. Each Ph.D. candidate must satisfy Lehigh's residence requirement. The residence requirement is intended to ensure that doctoral students spend a period of concentrated study and intellectual association with other scholars. Either two semesters of full-time graduate study or 18 credit hours of graduate study within a twelve-month period must be completed.

Individual departments may impose additional stipulations. Candidates should check with their advisers to be certain that they have satisfied their residence requirements.

Language requirements. Language requirements for the Ph.D. are the option of and in the jurisdiction of the candidate's department. Since proficiency in a language is not a university requirement, each department decides which languages, if any, constitute part of the doctoral program.

Qualifiers. Many departments require students who wish to enroll in doctoral programs to pass qualifying examinations. Since these examinations vary among departments, students should ask their advisers or department chairpersons for more detailed information. If a qualifying examination is not used, students should find out how and when eligibility to pursue doctoral studies is determined.

Admission to candidacy. With the help of an academic adviser, the student names the faculty members of the doctoral committee, a special committee formed to guide the student through the doctoral program. The committee is responsible for assisting the student in formulating a course of study, satisfying specific departmental requirements, submitting a suitable dissertation proposal, overseeing progress in research, and evaluating the completed dissertation. At least four faculty are appointed to the committee; one must be a member of an outside department. Committee membership must be approved by the university's graduate and research committee.

A doctoral student should apply for candidacy no later than one year after completion of the master's degree or its equivalent and after passing qualifying examinations if they are required by the major department. The prospective Ph.D. candidate must submit to the doctoral committee a written program proposal that includes a discussion of proposed dissertation research. Upon receiving approval of the proposal, the candidate submits the proposal, signed by the committee members, to the Graduate School for action by the graduate and research committee. The Graduate School will advise the student of the committee's decision.

If the dissertation research involves human subjects, university procedures must be followed.

General examinations. Examinations composed and administered by the members of the student's doctoral committee are designed to test the candidate's proficiency in a particular field of study. These examinations, which may be both written and oral, should be passed at least seven months before the degree is to be conferred. If a student fails the general examination, a second examination will be scheduled not earlier than five months after the first. If the results of the second examination are unsatisfactory, no additional examination is scheduled.

Dissertation and defense. The Ph.D. candidate is required to write a dissertation prepared under the direction of a Lehigh University professor. The dissertation must treat a topic related to the candidate's specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.

Upon approval of the advising professor and, if required by the department, secondary readers, the dissertation is submitted to the dean of graduate studies for inspection at least six weeks before the degree is to be conferred. Upon its return, the student should distribute copies of the draft to the members of the doctoral committee for review and for suggestions for revision. The candidate then schedules a dissertation defense before the doctoral committee, additional faculty members the department may add to the examining committee, and the general public.

After the dissertation has been defended and revised accordingly, the student must submit the finished dissertation to the dean of graduate studies for review by the university's graduate and research committee no later than two weeks before the degree is to be conferred. Two unbound copies must be delivered to the Graduate School office. One copy must bear the original signatures of the special committee members. In addition, the candidate must pay a microfilming fee of \$50 and present a bursar's receipt for the payment. Guidelines stipulating the standard form of the dissertation are available in the Graduate School office.

Doctor of Arts (D.A.)

The doctor of arts degree (D.A.) is offered to students preparing for careers in college teaching in the field of chemistry. The program requirements are similar to those for the Ph.D. with the following exceptions: (1) a broader distribution of graduate courses in the field, (2) a minor area of study for students interested in bidisciplinary preparation for two-year college teaching, (3) coursework and training in interpersonal awareness, (4) a supervised internship in college teaching, (5) and a research project appropriate to college teaching in the student's field of specialization.

Graduate Degrees in Business Administration and Economics

Candidates for admission to graduate study in the College of Business and Economics must provide the results obtained in either the Graduate Management Admission Test (GMAT) for degrees in business administration, or the Graduate Record Examination general test (GRE) and the subject test in economics for degrees in economics.

Master of Business Administration

The Master of Business Administration (MBA) degree program is designed to provide candidates with conceptual, analytical, and operational skills that are involved in the decision-making processes connected with managing human, physical, and financial resources. The MBA curriculum provides a blend of strong theoretical foundation together with practical application in the areas of accounting, organizational, behavioral, economics, finance, the legal environment, management, marketing, and quantitative methods.

Education in the business professions requires an

understanding of the various organizational functions and integrating these with internal and external aspects of the enterprise into the managerial process. The program encompasses generalized managerial competence, while permitting advanced concentration in such fields of specialization as finance, marketing, quantitative and behavioral facets of management, accountancy, economics, international trade and finance, and labor and industrial relations.

All candidates for entry into the MBA program are required to take the Graduate Management Admission Test (GMAT). Information concerning this test may be obtained at college and university counseling centers, or by contacting GMAT, Educational Testing Service, P.O. Box 6103, Princeton, N.J. 08541-6103.

Program prerequisites. Students entering the MBA program should have completed college-level coursework in principles of economics, calculus, and computer literacy. Although failure to complete these prerequisites will not necessarily result in denial of admission to the program, a student without them will be expected to complete the three prerequisites at Lehigh or elsewhere by the end of the first semester following matriculation into the program. If a student can demonstrate proficiency in a high-level programming language without formal coursework, he or she may petition to have the computer programming prerequisite waived.

The MBA curriculum. The minimum number of credit hours required for the MBA degree is thirty, normally consisting of ten courses. This minimum presumes that the foundation courses in the various functional fields were completed prior to entry into the MBA program. (A person who received a baccalaureate degree in business administration from an accredited institution may reasonably expect to have fulfilled the foundation course requirements, discussed in further detail below). This thirty-hour program may be completed in two semesters by taking fifteen credit hours each term, or by taking twelve credit hours each semester plus six during the summer sessions, or some other combination. The following four courses are required in this 30-hour format:

Acct 421	Information Systems for Managers
Econ 421	Managerial Economics
Mgt 423	Operations Management
Mgt 429	Managerial Policy and Decision-Making

In addition, six 400-level elective courses are to be selected from at least four functional areas, with no more than two courses being taken in any single area. A maximum of two of these six electives may be taken in academic departments at Lehigh outside the College of Business and Economics with prior permission of the MBA director and respective department chairperson. These other departments include Computer Science, Industrial Engineering, Psychology, and Social Relations.

For the candidate who has not completed one or more of the first ten foundation courses listed below, up to a maximum of forty eight credit hours is required in the MBA program. However, up to six required foundation courses may be waived outright upon the candidate providing evidence of satisfactory completion of equivalent coursework, or passing a proficiency examination in that subject area. In addition, four foundation courses are subject to limited waiver, with advanced courses being required as replacement-electives. The required coursework is:

Acct 403	Financial Flows and Accounting Measurements*
Acct 413	Managerial Accounting and Decision-Making**
Econ 401	Basic Statistics for Business and Economics*
Econ 408	Price Theory and Application*
Econ 409	Money, Banking, and Macroeconomic Analysis*
Fin 411	Financial Management**
Law 404	Legal Environment of Management*

Mgt 401	Quantitative Methods in Business and Economics*
Mgt 413	Organizational Behavior and Management**
Mkt 413	Marketing Management**
Acct 421	Information Systems for Managers
Mgt 423	Operations Management
Mgt 429	Managerial Policy and Decision-Making

In addition, three 400-level elective courses are to be selected, with no more than two courses being taken in any single area.

* Waiver policy: This course may be waived if a comparable course or courses (see the course-description section of this catalog) was taken with a grade of B- or better being earned not more than eight years prior to matriculation into Lehigh's MBA program.

** Limited waiver policy: This course may be waived depending on prior coursework and academic performance as determined on a case-by-case basis in consultation with the MBA director and respective department chairperson in accordance with guidelines established by the faculty. If the course is waived, an advanced graduate-level course in the same area may be required to be taken as one of the MBA elective courses.

Master of Science Degree in Business and Economics

The master of science degree is offered to students interested in pursuing graduate work in economics or in economics and business.

A minimum of thirty semester hours of coursework is required. At least eighteen of these hours must be taken in the College of Business and Economics. In addition, the student will be expected to pass comprehensive examinations in general economic theory and in one other field in the college.

To qualify for the master of science degree, the student must take the following courses in Economics, as part of his or her thirty semester hours of coursework:

408	Price Theory and Applications
415	Econometrics I
420	Advanced Macroeconomic Analysis
432	Advanced Microeconomic Analysis
456	Mathematical Economics

Master of Science Degree in Management Science

This degree is available to students as an interdisciplinary degree with the Department of Industrial Engineering. Students are admitted and may enroll in either the College of Business and Economics or the Department of Industrial Engineering. The master of science in the management science program is directed toward integrating the scientific method with the functional aspects of organizations. By investigating the application of quantitative methodology and systems analysis in the context of such areas as accounting, applied economics, finance, marketing, production, and public service, the program helps to develop a meaningful analytical perspective of business problems.

This integration provides the student with a broader perspective of managerial decision making in private enterprise and/or public administration. Students who have had prior exposure as undergraduates to engineering, business, economics, mathematics, or the physical sciences and who desire a quantitatively oriented business program are ideal candidates.

Management science graduates may pursue careers as staff specialists or as line managers who must deal with the increasingly complex problems of industrial, commercial, and public service organizations.

At the completion of the degree requirements, the student will have acquired an excellent background in the

various functional areas of business and economics. Included is a three-credit research project or practicum aimed at providing the student with professional exposure while still in a formal educational environment. Each student conducts an empirical investigation of an actual management problem and submits an individual written report.

Master of Science in Management of Technology

Lehigh's Master of Science program in Management of Technology (M.S. in MOT) equips scientists and engineers for general management responsibilities in technology-intensive firms and industries, and prepares them for such managerial responsibilities as:

- Creating or acquiring technical knowledge that can become the basis for new and improved products, process, and services
- Commercializing innovative products, processes, and services that embody new technical knowledge
- Generating profits from technical and commercial developments

Graduates will be equipped to participate in strategic and tactical decisions that are affected by technology, and be effective agents of change for improving the technology-management process.

More specific and complete details of the program are reflected on page 51. Applicants must submit a complete application, including data sheet, official transcripts from all undergraduate and graduate institutions, two letters of recommendation, a personal essay, and test scores from the Graduate Record Examination (GRE) or the Graduate Management Aptitude Test (GMAT). Complete applications must be received by June 15 to be considered for the Fall semester. A brochure describing the MOT program, an application for admission, and any additional information may be obtained by contacting either Alden S. Bean (director, Center for Innovation Management Studies, 215-758-3427), or Kathleen A. Trexler (Assistant Dean, College of Business and Economics, 215-758-3418) at Lehigh University, 621 Taylor Street, 37 Rauch Business Center, Bethlehem, Pa 18015.

Doctor of Philosophy

The Ph.D. degree in business and economics is designed to provide advanced knowledge and the capacity to carry on independent research in various areas of business and economics. Holders of the Ph.D. are normally employed in academic positions in departments of economics or in schools of business administration, or in policy analysis and research positions in banks, business, government, and research organizations. Employment opportunities are excellent for holders of this degree.

The Ph.D. program requires a minimum of 48 semester hours of study (including dissertation) beyond the master's degree or 72 hours of study beyond the bachelor's degree. Each student is expected to choose three major fields of specialized study. Economic theory must be included as one of the major fields. Each student must take a research core of twelve hours and prepare for written and oral comprehensive examinations in the major fields. The chairperson of the doctoral committee will help to arrange a plan of study suitable for each student's program and to prepare the student to pass the examinations.

Major fields of specialization that are normally available include economic theory, international economics, labor economics, managerial economics, money and banking, finance (corporate, financial markets and institutions, investments), and public finance.

Under the guidance of a dissertation chairperson and committee formed after passing of the examinations, the candidate undertakes research culminating in an acceptable dissertation. The Ph.D. is awarded upon the successful completion of the doctoral dissertation and its oral defense.

Graduate Degrees in Education

Lehigh's College of Education offers only graduate degree programs. Students enrolled in the College of Education should check with their adviser for a list of regulations and requirements governing their degree programs.

Financial assistance. The College of Education, because it does not offer many undergraduate courses, cannot provide teaching assistantships for graduate students. Graduate assistantships and research assistantships are available in the College and in various administrative offices on campus. In addition, graduate students may be recommended for a limited number of fellowships and scholarships, which are awarded by the Graduate School.

Lehigh's Centennial School, a laboratory school for socially and emotionally disturbed children, provides employment for some Lehigh education students. Graduate students may apply for teaching internships, which pay tuition plus salaries.

Master of Education (M.Ed.)

This degree is offered in the following professional specializations: elementary education, secondary education, special education, educational administration, community counseling, elementary and secondary school counseling, reading, and social restoration. Degree requirements vary from program to program.

Master of Arts (M.A.)

The master of arts degree offered in the field of secondary education provides a major in education with an academic specialty. The student must take eighteen credits of graduate work in education plus twelve credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: classical languages, modern foreign languages, English, mathematics, economics, government, social relations, history, international relations, or physical and natural sciences.

Master of Science (M.S.)

The master of science degree is awarded in educational technology.

Educational Specialist (Ed.S.)

Specialized post-master's degree programs for practitioners are available in school psychology, and special education.

Certification and Concentration Programs

In addition to offering master's degrees, the College offers state certifications in various professional specialties. The College of Education also offers special twelve to fifteen credit programs that provide concentrations in gifted education and education of the severely/multiply handicapped.

Doctor of Education (Ed.D.)

The doctor of education degree program provides specialized study in elementary education, special education, educational administration, reading, and educational technology. Successful professional experience is required for admission to candidacy for this degree in most programs.

The requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the following exceptions: language examinations are not required; and a statistics competency examination is required. The residence requirement for the Ed.D. is the same as that for the Ph.D.

Doctor of Philosophy (Ph.D.)

The College of Education also offers the Ph.D. degree to students enrolled in the fields of school psychology, special education, and counseling psychology.

Graduate Study for Engineering Professionals

All departments within the College of Engineering and Applied Science offer a cooperative program that allows an engineer working in industry to further his or her education while retaining a professional position. Students enrolled in this program may pursue an M.S., M.Eng., or Ph.D. at Lehigh while employed full-time, completing the course requirements for the degree in a period of time that does not greatly exceed that spend by full-time graduate students in residence at Lehigh.

A professional interested in participating in this program applies to the Graduate School through a participating department. (See course listing for each department for specific areas of research, courses available, and departmental requirements.) When accepted, he or she chooses the track best suited to his or her individual needs. Each track allows a student to obtain a master's degree; then, a highly motivated professional may pursue a doctoral degree if he or she chooses.

In any case, however, the residency requirements for the master's degree are fulfilled by spending two semesters at Lehigh as a resident graduate student. During the intervening semesters or summers, the student returns to the full-time, professional position. (It is best to spend a fall semester and spring semester on campus to allow maximum flexibility in course selection.)

The thesis or project required for the degree sought is decided upon through mutual consultation among the student, the adviser at Lehigh, and the supervisor in industry. The thesis or project work is begun during the student's first semester at Lehigh with the body of work performed when the student returns to his or her position in industry. Then, the thesis is completed when the student returns to Lehigh.

Each student chooses a faculty member at Lehigh who serves as academic adviser, helps the student select appropriate courses, and oversees the thesis or project work. The student also has a corporate adviser, preferably the person to whom the student reports, or a senior experienced member of the corporate staff. It is hoped that in many cases the interactions among faculty member, corporate adviser, and student/employee will form the basis for a continuing relationship between the university and industry that will allow significant and ongoing research areas to be addressed by a sequence of students seeking advanced degrees.

While enrolled in the program, the student remains an employee of the company or corporation and receives his or her salary as usual. (Lehigh considers that salary a matter to be arranged between the student and the employer.) Students are responsible for the full tuition due the university and are reimbursed by their employers according to company policy. Generally this means that students must make satisfactory progress towards the degree sought and achieve acceptable grades in coursework.

Because the program requires additional work by faculty and staff, the company agrees to donate a sum equal to the university's tuition to the department in which the personnel are enrolled. In addition, companies agree to assist the department in meeting laboratory, computer, and other research costs that accrue during the student's research or project work.

The program is structured to be flexible enough to meet the needs of professional participants; the choice of approach will depend on the circumstances that pertain to particular industries and to the needs and interests of individual students.

A brochure describing this program in detail is available from the College of Engineering and Applied Science, 19 Memorial Drive, West, Lehigh University, Bethlehem, Pa. 18015.

Graduate School Organizations

The Graduate and Research Committee

The graduate and research committee consists of twelve members representing the faculties of Lehigh's colleges: four from the College of Arts and Science; two from the College of Business and Economics; four from the College of Engineering and Applied Science; and two from the College of Education, plus four ex officio members and three non-voting student members, two graduate students and one undergraduate.

The committee formulates policies and regulations on graduate education, and it recommends policies and procedures for research-related activities. The committee interprets and applies faculty rules governing graduate students and degrees, including questions concerning student petitions and appeals.

Graduate Alumni Committee

The Lehigh University Alumni Association has established a graduate alumni committee. The committee is composed of distinguished Lehigh graduate alumni and is chaired by Stephen P. Link, '85, M.B.A. '91. The committee will provide leadership deepening the involvement of graduate alumni in Lehigh affairs.

Graduate Student Council

The graduate student council, comprised of one graduate student from each academic department, represents the graduate student community regarding graduate programs and graduate student life at Lehigh. It provides a forum for discussion with university officials and committees. Graduate students selected by the graduate student council are non-voting members of the graduate and research committee and the educational policy committee. In addition, four graduate student council members serve on the dean's advisory committee in order to provide a liaison between the dean of graduate studies and the graduate student council.

Besides functioning as a forum for discussion, the graduate student council maintains a graduate student center. The council plans social events and disseminates information in order to facilitate communication among graduate students.

Interdisciplinary Graduate Study and Research

In addition to offering graduate degrees within academic departments, Lehigh University offers interdisciplinary graduate degrees in the fields of applied mathematics, applied social research, biology, clinical chemistry, management science, manufacturing systems engineering, molecular bioscience and biotechnology, physiological chemistry, and polymer science and engineering.

In addition, Lehigh's 29 interdisciplinary research centers and institutes address the research needs of government, industry, and society. Organized to recognize research efforts in interdisciplinary problem areas, they supplement the university's academic departments. Graduate students pursuing M.S. and Ph.D. degrees in academic departments as well as students enrolled in interdisciplinary degree programs may pursue research opportunities in the various centers.

A complete listing of research centers, institutes, and other research organizations appears following the section on interdisciplinary graduate programs.

Financial assistance. Teaching assistantships and fellowships are provided by individual academic departments, while research assistantships are available through both academic departments and research centers. Students interested in research are encouraged to seek

appointments with members of the faculty working in their area of special interest, with department chairpersons, or with center or institute directors.

Interdisciplinary Graduate Programs

Several interdisciplinary programs are offered to the Lehigh graduate student.

Applied Mathematics

Lehigh University offers interdisciplinary programs leading to the degrees of Master of Science and Doctor of Philosophy in Applied Mathematics.

Students may participate in the program either through the Division of Engineering Mathematics within the Department of Mechanical Engineering and Mechanics or through the Division of Applied Mathematics and Statistics within the Department of Mathematics.

The Ph.D. program is aimed at students with a background in mathematics, the sciences, or engineering who wish to obtain a thorough training and to develop their research ability in applied mathematics. Students will be admitted to one of the two divisions according to background and interests.

Seminar series in engineering science and applied mathematics in which visitors, faculty and students discuss current research, are available.

Admission Procedure. Applications are invited from students with backgrounds in engineering, mathematics or the sciences.

A complete application should include undergraduate and graduate transcripts, the aptitude part of the GRE, and at least two letters of recommendation. Foreign students must submit evidence of proficiency in English.

All applications are reviewed by the Department of Mathematics and Department of Mechanical Engineering and Mechanics. Students whose area of specialization is Applied Mathematics must register in one of the two departments and specify on their application the department of their choice. For application forms and information, write:

Prof. Philip A. Blythe, Head
Division of Engineering Mathematics
Packard Laboratory #19
Lehigh University
Bethlehem, PA 18015 Tel. (215) 758-3782

Prof. Gregory T. McAllister, Head
Division of Applied Mathematics & Statistics
Christmas-Saucon Hall #14
Lehigh University
Bethlehem, PA 18015 Tel. (215) 758-3730

Lehigh University
Alumni Memorial Building 27
Chairman of Coordinating Committee
Applied Mathematics Program
Bethlehem, PA 18015-9988

Financial Aid. Teaching assistantships are offered by both departments, and university fellowships and scholarships are offered by the Graduate School. Research assistantships are sponsored by governmental agencies and industry.

M.S. Program. A master's program must include at least thirty semester hours of courses.

Students in the Mathematics Department must pass a comprehensive examination. They may replace up to six hours of course work with a thesis. Research credits are obtained by registering in MATH 490—Mathematics Thesis.

Students registered in the ME/Mechanics Department must submit a thesis, which may replace up to six hours of course work. No comprehensive examination is required. Research credits are obtained by registering in EMA 490—Engineering Mathematics Thesis.

Ph.D. Program. The master's degree is not a requirement for the Ph.D.

A candidate entering at the bachelor's level must satisfy only the course requirements of the master's degree in the

division in which he/she is enrolled. The candidate's advisor will recommend courses that help in preparing for the qualifying exams. Any additional course requirements will be determined by the student's dissertation committee. Students registered in the ME/MECH department obtain research credits by registering in EMA 499—Engineering Mathematics Dissertation.

Students registered in the Mathematics Department must satisfy the foreign language requirement. They may obtain research credits by registering in MATH 499—Mathematics Dissertation.

It is recommended that the qualifying examination be taken at the beginning of the fourth semester for students entering at the bachelor's level and at the beginning of the second semester for students entering with a master's degree.

The examination consists of three written tests. One is in analytical methods, one is on numerical methods or discrete mathematics, and one is on a topic from the physical or mathematical sciences as approved by the candidate's division.

Applied Social Research

The applied social research program leads to the Ph.D. degree. The objective is to train specialists to consult on and to conduct applied social science research involving individuals, groups and social settings in business and industry, educational organizations, medical and human services programs, and governmental planning and policy making agencies. The interdisciplinary program is sponsored by the departments of psychology, social relations, and government in the College of Arts and Science, by the College of Business and Economics, by the College of Education and by the Center for Social Research. The training program includes relevant research techniques and strategies from the disciplines these departments and colleges represent.

In recent decades specialized methods have been developed for conducting research involving economic projections, market research, environmental and social impact analyses, experimental research, and program evaluation and to gather data for governmental and private planning and policy analyses. The methods have common features such as research planning, design and implementation, measurement design, sampling procedures, statistical analyses, computer applications and data management, interpretation and evaluation of results, and decision making based on the results.

The aim of the applied social research program is to develop methodological generalists who are knowledgeable in and have experience with the rather wide variety of methods required to conduct research in business, educational, social service, governmental and planning organizations. In contrast to academic settings where the tendency is to become increasingly specialized, the need in applied settings is for expertise in solving problems requiring a variety of social science research skills. In addition to a broad methodological background, the program provides the student with experience in conceptualizing, designing, implementing, interpreting, and communicating applied research.

Program requirements. Entrance requirements are a master's degree in social science, psychology, education or business, or in a field deemed by the coordinating committee to provide relevant background and sufficient quantitative skills to give some assurance of success in the program. A program of study and research will include courses in statistics, research design, measurement design, computer methods and research applications. A qualifying examination is given after 18-20 credits of work. Advanced courses, a research internship and a dissertation complete the requirements. Specifics of a student's program are to be worked out with a faculty adviser and depend on the student's past experience, educational and occupational goals.

Financial aid. Research assistantships, teaching assistantships, and fellowships or scholarships are available.

Application for admission. Requests for further

information and for applications for admission should be directed to: Applied Social Research Ph.D. Program Coordinating Committee, Center for Social Research, Lehigh University, 516-520 Brodhead Ave., Bethlehem, Pa. 18015.

Biology

Graduate study leading to the M.S. and Ph.D. degree in biology is available in an interdepartmental program involving the departments of molecular biology, earth and environmental sciences, and psychology. Students should contact the department most closely aligned with their interests for specific information for M.S. and Ph.D. requirements.

Master's degree requirements. The requirements for the M.S. degree include thirty credits of graduate coursework, eighteen of which are at the 400 level, and successful completion and defense of a research project.

Ph.D. requirements. Course requirements for the Ph.D. in Biology are determined on an individual basis by the student and the dissertation committee.

Near the time of completing the requirements for the M.S. degree, a student who wishes to pursue a Ph.D. takes a written and oral qualifying examination. Upon successful completion of this examination (it may be taken no more than twice), the student, in consultation with the research advisor, selects a dissertation committee.

The centerpiece of the doctoral program is a concentrated research effort that culminates in a significant contribution to the field of biology. Sometime prior to seven months before finishing the dissertation, the student must pass a general examination administered by the dissertation committee. The nature of this examination is determined by the dissertation committee.

The defense of the dissertation serves as the final examination for the doctorate. It is expected that the results of the dissertation research will be published in primary journals.

For further information, contact Vassie C. Ware, Graduate Coordinator, Dept. of Molecular Biology, Mountaintop Campus 111, Lehigh University, Bethlehem, PA 18015.

Clinical Chemistry

The M.S. program in clinical chemistry is offered by the department of chemistry in cooperation with local hospitals. It is directed toward training clinical laboratory scientists to be active in hospital-based and industrial laboratories in both patient sample service and new product development. The program requires fulfillment of a clinical laboratory practicum as well as a research project at the M.S. level. The core requirements for the degree are:

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry II (3)
Chem 332	Analytical Chemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
Chem 437	Pathophysiological Chemistry (3)
Chem 421	Chemistry Research (1-4)
	Clinical Laboratory Practicum

Electives or courses that may be substituted, upon an approved petition, for core requirements in clinical chemistry can be drawn from those listed in the Ph.D. programs in molecular biology or physiological chemistry (see below).

Students may be admitted into this program from undergraduate majors in chemistry, biology, medical technology, or other areas of the biochemical life sciences. One semester of undergraduate physical chemistry is required for the M.S. in clinical chemistry although in some cases this course may be taken while enrolled as a graduate student but for no graduate credit. Graduates of the program are encouraged to continue their education toward the doctorate in any one of the several biological chemistry programs offered at Lehigh.

Management of Technology

Lehigh's Master of Science Program in Management of Technology (M.S. in MOT) equips scientists and engineers for general management responsibilities in technology-intensive firms and industries. The program prepares graduates for managerial responsibilities of three kinds:

- Creating or acquiring the technical knowledge that can become the basis for new and improved products, processes and services
- Commercializing innovative products, processes and services that embody new technical knowledge
- Capturing profits from technical and commercial developments

Graduates will be equipped to:

- Participate in strategic and tactical decisions that are affected by technology
- Be effective agents of change for improving the technology-management process.

Program requirements. The program consists of 33 hours of required course credits, nine hours of electives and a three hour master's thesis for a total of 45 credits. There are three options for completing degree requirements:

Full-Time Option: A 12-month program (three semesters) requiring 15 credit hours per semester including the summer. Students should define their thesis project options by the time of admission. Permission of the Program Director is required.

Released-Time Option: A 21-month program (five semesters) requiring the student to be "released" for 3-6 hours per week during normal afternoon working hours to participate in the program.

Part-Time Option: A three-year program (nine semesters) requiring two courses per semester during the academic year and one course during each summer session.

Curriculum. Foundation courses establish a solid base of knowledge about the economic and historical importance of technology to industry and society and build competence in the use of financial and accounting tools to support technology-management decision-making. These courses give special attention to the issues and problems encountered by technology managers and to the distinctive challenges of supervising and leading technical professionals.

- Technology and Economic Analysis
- History of Industrial Technology
- Managerial Finance
- Cost Management and Accounting
- Managing and Leading Technical Professionals

Functional Core courses prepare students to manage and lead cross-functional technical projects by developing project-management skills and by studying the management responsibilities associated with other major functions encountered in most technology intensive industrial firms. These courses emphasize both the strategic concepts and the operational skills associated with technology management in each functional area.

- RD&E Project Management
- Information Technology & Operations Management
- R&D Management

Integrative courses emphasize the formulation and implementation of overall technology strategies for companies ranging from individual businesses to large, complex firms. Integrative courses also provide an understanding of the roles played by scientific and technical institutions outside the firm, including government regulatory and standard-setting organizations, in the technological innovation process.

- Science and Technology Policies and Institutions
- Science, Technology and Competitive Strategy

Elective courses allow students to pursue special interests. In addition to a menu of elective courses within the MOT program, selected technical courses offered by other Lehigh

departments may also be taken as electives, with the approval of the Program Director.

- Total Quality Management
- Management of Information Technology
- Science, Technology and International Business
- Analysis of Emerging Technologies
- New Product Planning and Development
- Diffusion and Implementation of Technology

Admission

The MOT program is intended for students with undergraduate degrees in science or engineering and at least four years of industrial experience. Students with undergraduate degrees in other fields will be considered based on employers' recommendations and other qualifications.

Applicants must submit a complete application, including data sheet, official transcripts from all undergraduate and graduate institutions, two letters of recommendation, a personal essay and test scores from the Graduate Record Exam (GRE) or the Graduate Management Aptitude Test (GMAT). Incomplete applications will not be considered. Complete applications must be received by June 15 to be considered for the Fall semester.

Inquiries

For a brochure describing the MOT program, an application for admission, or any additional information, please contact: Alden S. Bean, director, Center for Innovation Management Studies, (215) 758-3427, or Kathleen A. Trexler, Assistant Dean, College of Business and Economics, (215) 758-3418, Lehigh University, 621 Taylor Street, 37 Rauch Business Center, Bethlehem, PA 18015.

Center for Innovation Management Studies

The M.S. in MOT program is affiliated with Lehigh's Center for Innovation Management Studies (CIMS), a National Science Foundation-supported industry/university cooperative research center for the study of technological innovation and its management. CIMS is the hub of a national network of industrial corporate sponsors and academic research associates. The MOT program will draw upon this network of industrial, government and academic colleagues for guest lecturers and seminar speakers throughout the program.

Management Science

The industrial engineering department, in conjunction with the department of management and marketing, offers an interdisciplinary degree in management science.

The management science program is directed toward integrating the scientific method with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as accounting, finance, marketing and production. This integration provides the student with a broader perspective toward managerial decision making in private enterprise and public administration.

Undergraduates with a background in engineering, business, economics, mathematics, or the physical sciences who want a professional career as a staff specialist in management science are appropriate candidates. In addition, those candidates who intend to seek line manager positions find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The candidate is assumed to have acquired basic competence in the areas of accounting, marketing, corporate finance, production, data processing, microeconomics, linear algebra, calculus, statistics, and introductory operations research. The minimum program consists of thirty hours.

Required coursework

IE 418	Simulation
Mgt 321, IE 334 or Mgt 413	Organization Behavior Workshop Organizational Planning and Control or Organization Behavior and Management
Eco 421	Managerial Economics
IE (Mgt) 430	Management Science Project
nine hours of quantitative methods	
six hours selected from a functional area	
three hours free elective	

Sample program

IE 418	Simulation
Mgt 413	Organization Behavior Workshop
IE (Mgt) 430	Management Science Program
Eco 421	Managerial Economics
IE 316	Advanced Operations Research Techniques
IE 417	Mathematical Programming
Eco 455	Econometric Models
IE 419	Sequencing and Scheduling
Fin 430	Financial Management
Fin 431	Advanced Investment Analysis and Portfolio Management

Manufacturing Systems Engineering

Lehigh's interdisciplinary graduate program leading to the master of science degree in manufacturing systems engineering (MSE) is sponsored by all the engineering departments in the College of Engineering and Applied Science and is managed by the Center for Manufacturing Systems Engineering. In addition, the College of Business and Economics participates in teaching management and other business aspects of manufacturing systems.

The graduate curriculum in manufacturing systems engineering is designed to develop engineers who can design, install, operate, and modify manufacturing systems and develop products using a knowledge of the interplay involving people, materials, processes, equipment, facilities and logistics. The program integrates systems perspectives with interdisciplinary education and training.

Program requirements. The M.S. program in manufacturing systems engineering may be completed as a one-year, full-time program beginning each January, however, students may pursue an additional semester. It requires a minimum of 30 credit hours of graduate study. The program is structured as follows:

Spring semester

Required courses:

MSE 421	Managing the Manufacturing Life Cycle (3)
MSE 423	Product Design/Analysis (3)
MSE 427	Production Systems (3)

Summer session (ten weeks)

One week study tour of industry visiting selected manufacturing plants, design centers and research facilities. Students and faculty analyze the manufacturing strategies, systems and modern technologies used in each of the visited facilities.

The summer semester also provides opportunities for meeting elective requirements and completion of thesis/project and research requirements.

MSE students are required to pursue a six credit thesis or a three credit project to complete their Master's degree. Students are expected to register for three credit hours towards their thesis or project in the summer.

MSE 451. Manufacturing Systems Engineering Project (3)
In depth study of a problem in the area of manufacturing systems engineering. The study should lead to specific conclusions embodied in a written report.

OR

MSE 490. Manufacturing Systems Engineering Thesis (6)**Fall semester****Required courses:**

MSE 425	Production Planning and Resource Allocation (3)
MSE 431	Technological Innovation in the Manufacturing Organization (3)
MSE 433	Technology and the Factory of the Future (3)

Additional Requirements. There are weekly seminar periods, laboratory and tutorial sessions, together with industry tours and meetings with executives from industry at which attendance is required.

Elective courses (6 or 9 credit hours): In order to complete their thirty credit hour minimum, students are required to take three approved elective courses unless they register for a thesis (6 credit hours) in this case they are required to take only two courses.

Elective courses should be selected, in consultation with an academic adviser, from five technical and business areas related to Manufacturing Systems Engineering. These areas include:

- design
- materials, processes and quality control
- automation, control systems, and computer integration
- computer and information systems
- business, management, organization and operations research

In addition to the regular classroom work, this program includes extensive use of Lehigh's CAD, CIM, AI, and robotics and manufacturing technology laboratories, as well as a variety of educational features to foster informal learning.

Admission

- A bachelor's degree in engineering or in another appropriate science is required.
- Candidates enroll in the MSE program through one of the university's engineering departments depending on their individual MSE specialization and interests.
- All candidates must follow the admission procedures and standards established by Lehigh University's Graduate School.
- Students enrolling in this program will be both industrial returnees and students with a B.S. degree going straight through college.

Qualified students completing their undergraduate degree requirements by May or June may apply to participate in the work-study internship program described below. Students graduating in December may apply to enroll in the MSE program immediately thereafter.

Industrial internships.* A special work-study internship program has been established as an option for qualified applicants desiring industrial experience before beginning the MSE program in January. A number of these industrial internships are available.

This intern program permits an applicant graduating with a B.S. degree in May or June to work with a participating company in an engineering or related science capacity for six to seven months before entering the MSE program.

Financial aid.* A number of graduate fellowships are available for qualified MSE applicants on a competitive basis.

Special Activities Fee. In addition to the applicable Lehigh University tuition, the MSE Program requires a special activities fee of \$2,300 for 1990. Tuition and fees are expected to increase on a yearly basis.

Inquiries. For a brochure describing the MSE program, an application for admission (which includes an application for financial aid), or any additional information, please contact: Keith M. Gardiner, director, Center for Manufacturing Systems Engineering, H.S. Mohler Laboratory #200, Lehigh University, Bethlehem, Pa. 18015. (215) 758-4667.

* Industrial internships and financial-aid may not be available to foreign applicants.

Molecular Bioscience and Biotechnology

This interdisciplinary program leads to the degree of Master of Science in Molecular Bioscience and Biotechnology. The program is designed as a broad-based introduction to advanced study in the fundamental bioscience and engineering that is the foundation of modern biotechnology. Students are enrolled through the departments of molecular biology, chemistry, or chemical engineering and take a core set of courses in molecular cell biology, biochemistry, and biochemical engineering, supplemented with advanced level courses in these three areas. Full-time registrants conduct research under the direction of faculty members of Lehigh University's Center for Molecular Biosciences and Biotechnology. Students wishing to continue beyond the M.S. degree can enter from this program into Ph.D. programs in Molecular Biology, Biochemistry, or Chemical Engineering.

The degree requires completion of thirty credits, eighteen of which must be at the 400 level. The required core courses, representing eighteen of the thirty credits, are:

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry II (3)
ChE 341	Biotechnology I (3)
ChE 342	Biotechnology II (3)
MBio 345	Molecular Genetics (3)
MBio 495	Cell Biology (3)

With the consent of the M.S. program coordinator, students may petition for substitution of courses equivalent to the core courses. The substitutions must receive the approval of the department responsible for the course.

With the guidance of the student's advisor and the M.S. program coordinator, the remaining twelve credits must be drawn from the following approved 400 level courses:

MBio 415; MBio 450; MBio 461; MBio 462
ChE 444; ChE 445; ChE 450
Chem 423; Chem 424; Chem 437; Chem 450; Chem 467;
Chem 468; Chem 469; Chem 470; Chem 471; Chem 472;
Chem 473; Chem 476

no more than 6 credits from the following 400 level approved lab courses:
MBio 463; MBio 464; ChE 446; Chem 479; Chem 480

no more than 6 credits from the following 400 level approved seminar courses:
MBio 406; MBio 466; ChE 448; Chem 435; Chem 477

a minimum of 3 credits of the following:
MBio 407; ChE 480; ChE 481; Chem 421

All students must (a) register for 6 credits of research, successfully complete a research project under the direction of a faculty member of the Center for Molecular Biosciences and Biotechnology, and submit a written report that is approved by the research advisor, the admitting department, and the M.S. program coordinator or (b) complete 6 credits of advanced level course work approved by the M.S. program coordinator and pass a Comprehensive Examination administered by the faculty from the Center for Molecular Biosciences and Biotechnology.

For further information, contact Janice A. Phillips, director, or Jeffrey A. Sands, co-director, Molecular Bioscience and Biotechnology Graduate Program, Jacocca Hall, Lehigh University, Bethlehem, PA 18015.

Physiological Chemistry

The graduate program in physiological chemistry leads to the M.S. and Ph.D. degrees. This curriculum prepares individuals who want to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: nuclear medicine, medicinal chemistry, chemical and experimental parasitology, invertebrate pathobiology, comparative immunology, and chemical physiology. The core course distribution and selection of electives may be altered to reflect the area of specialization.

Core Courses

Students select at least six of the following core courses:

Chem 303	Nuclear and Radiochemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 371	Elements of Biochemistry I (3)
Chem 423	Bio-organic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 479	Biochemical Techniques (3)
Chem 435	Advanced Topics in Clinical Chemistry (3)
Chem 437	Pathophysiological Chemistry (3)
Chem 477	Topics in Biochemistry (1-3)
Biol 367	Molecular and Cellular Biophysics (3) or any course in statistics

Students, with the consent of their graduate committee members, may petition to substitute equivalent courses for some of the required ones. The substitution must be approved for the student's area of research concentration. In addition, each student selects, with the guidance of the committee, sufficient courses from the following to satisfy the requirements of the Graduate School.

Chem 358	Advanced Organic Chemistry (3)
Chem 372	Elements of Biochemistry (3)
Chem 421	Chemistry Research (1-4)
Chem 423	Bio-organic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 441	Chemical Kinetics (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 458	Topics in Organic Chemistry (3)
Chem 476	Microbial Biochemistry (3)
Chem 480	Advanced Biochemical Preparations (1-3)
Chem 481	Chemistry Seminar (1-6)
Biol 133	Invertebrate Zoology (3)
Biol 461	Molecular Cell Biology (3)
Biol 353	Virology (3)
Biol 402	Comparative Animal Physiology (3)
Biol 405	Special Topics in Biology (microbiology) (3)
Biol 415	Cytochemistry (3)
Biol 464	Ultrastructure Laboratory Techniques (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)

Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other areas of the life sciences.

All students in the doctor of philosophy program are required to satisfy one foreign language requirement and pass a qualifying examination. The completion of a research project is required of M.S. students. A dissertation is required of Ph.D. candidates.

For further information, contact Ned D. Heindel, Chemistry Department, Lehigh University, 6 E. Packer Avenue, Bethlehem, Pa. 18015.

Polymer Science and Engineering

Lehigh has a diverse group of faculty members with strong, primary interest in polymer science and engineering. In

order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through the Center for Polymer Science and Engineering (CPSE), and its academic polymer education committee. Polymer faculty from traditional departments of chemical engineering, chemistry, and materials science and engineering, physics, and mechanical engineering and mechanics, are participants of the CPSE.

There are two ways in which qualified graduate students, with degrees in the above or related fields, may participate. They may pursue graduate studies within an appropriate department. Departmental procedures must be followed for the degree sought. The student's adviser may be in that department, or in another department, or research center. In this case, the student receives a normal departmental degree, with emphasis in polymer courses and research.

Alternatively, students may elect to pursue studies toward an interdisciplinary degree in polymer science and engineering. The procedures for this latter case are summarized as follows.

M.S. in polymer science and engineering. For the M.S., the student's program must include: not less than thirty credits of graduate work; not less than eighteen credits of 400 level course work, and not less than eighteen credits of course work in the major, of which fifteen must be at the 400 level. The program must include six course credits in the student's admitting department, six research credits, and a research report or thesis to the satisfaction of the faculty advisor, to be filed with the polymer education committee.

Required courses:

ChE (Chem) 388	Synthesis and Characterization Lab (3)
ChE (Chem) 393	Physical Polymer Science (3)
Mat 343	
ChE (Chem) 394	Organic Polymer Science (3) Research (6)

Three 400 level polymer courses to be selected from the following list (list may vary slightly from year to year):

Mat 409	Fibers (3)
Chem Eng 428	Rheology (3)
Phy 472	Polymer Physics (3)
Chem Eng (Chem) 483	Emulsion Polymers (3)
Chem Eng (Chem Mat) 482	Engineering Behavior of Polymers (3)
Chem Eng (Chem Mat) 485	Polymer Blends and Composites (3)
Chem Eng 486	Polymer Processing (3)
Chem 489	Organic Polymer Science II (3)
Chem 491	Physical Chemistry of Organic Polymer Coatings (3)
Chem Eng (Chem) 492	Topics in Polymer Science (3)
Chem 493	Organic Chemistry of Organic Polymer Coatings (3)
Chem Eng (Chem Mat) 487	Polymer Interfaces (3)

Courses in the admitting department must include one of the following:

ChE (Chem) 400	Chemical Engineering Thermodynamics (3)
Chem (ChE) 445	Elements of Physical Chemistry (4)
Mat 401	Thermodynamics and Kinetics I (3)

plus one other 300 or 400 level non-polymer related course from their admitting department.

Ph.D. in polymer science and engineering. For the Ph.D., the student must satisfactorily complete a qualifying examination administered by the polymer education committee, satisfactorily complete graduate course work determined in consultation with the doctoral committee, pass a general examination administered by the polymer education committee, and defend to the satisfaction of the

doctoral committee, a dissertation in the field of polymer science and engineering. Students deficient in polymer science or related topics may be required by their committee to take remedial course work.

The doctoral committee consists of the research adviser, at least two members of the center for polymer science and engineering, and at least one outside person. The committee's composition is subject to approval by the polymer education committee and the graduate and research committee of the university.

For more information, write to Dr. M.S. El-Aasser, director, Center for Polymer Science and Engineering, Iacocca Hall, Mountaintop Campus, Lehigh University, Bethlehem, PA 18015, or Dr. L.H. Sperling, chairman, Polymer Education Committee, Whitaker Laboratory, Lehigh University, 5 E. Packer Avenue, Bethlehem, PA 18015.

Research Centers and Institutes

Lehigh has developed a number of centers and institutes to provide greater research and academic opportunities for primarily graduate students and faculty. Centers and institutes are generally interdisciplinary and complement the scholarly activities of academic departments and represent scholarship and research based on the expertise and capabilities of a group of faculty members. Frequently, centers relate to the broad-based research needs of government, industry, and the social community. (Please note as of January 1, 1994, Lehigh's area code will change to 610.)

BioProcessing Institute

The BioProcessing Institute coordinates the education and research activity in the bioprocessing area of the Chemical Engineering Department at Lehigh University. The main focus of the research of this institute is on the processing problems related to the manufacture of products of interest to the biotechnology industries.

Research interests. The research thrusts of the institute include: fundamentals kinetics of microbial, mammalian and plant cell and enzyme systems; design and scale-up of bioreactor and bioseparation systems; modeling and control of bioreactor and bioseparation systems; development of instrumentation for the on-line monitoring of biological unit operations; and development of novel separation and purification schemes for recovery of biologically active macromolecules, antigens, and antibodies.

Specific examples of projects recently carried out within the institute are: development of scanning laser fluorometry and Fourier transform infrared spectroscopy for the on-line monitoring of substrate, product and cell concentrations; analysis of diffusional limitations and medium formulation for gel-entrapped mammalian cell systems; design of reaction systems for secondary metabolite production by plant cells; fundamental studies of separation systems such as continuous chromatography, aqueous two-phase extraction, and electromolecular propulsion; kinetics of enzyme production by cellulolytic fungi/actinomyces; kinetics of protein degradation and optimization of whey hydrolyzate as a substrate for the lactic acid fermentation; plasmid stability in recombinant *Saccharomyces cerevisiae* and CHO cells; and proteolytic degradation in recombinant *E. coli*.

The research is conducted in Building A, Mountaintop Campus where the laboratories for the Department of Molecular Biology and Biochemistry research group, the Department of Chemical Engineering, the Emulsion Polymers Institute, and the Chemical Process Modeling and Control Center are also located. Because of the interdisciplinary nature of the research, projects typically involve joint supervision by faculty from Chemical

Engineering, Molecular Biology, and Chemistry/Biochemistry.

The BioProcessing Institute presently occupies 9000 square feet of laboratory space in the C wing of Building A of the Mountaintop Campus. The institute is equipped with an array of pilot-scale, computer-controlled bioreactors, monitored and controlled by IBM-PC's or Leeds & Northrup MAX 1 Distributed Digital Control Unit. In addition, numerous small-scale reactors are available for batch and continuous culture work. Key emerging monitoring systems used on the pilot-scale fermentation equipment include a UTI Quadropole Mass Spectrometer, BioChem Technology Fluorometer System, and a Digilab/Bio-Rad FTS 60 FTIR Spectrophotometer. Pilot-scale separations capability is being developed and currently includes a Millipore Pellicon Unit, and Premier Mill beadmill for cell disruption.

The fermentation and separations facilities are supported by analytical equipment and facilities including UV/visible spectrometers, isocratic and gradient HPLC's with refractive index and variable wavelength UV/visible detectors, gas chromatographs with FID and TCD detectors, YSI glucose analyzer, Branson cell sonifier, incubator/shakers, laminar flow hood, microscopes, etc.

Mammalian cell cultivation is conducted in a recently constructed class 1000 laboratory equipped with CO₂ incubators, vertical laminar flow hoods, a Belco roller bottle apparatus, Millipore Milli-Q purification system, inverted microscope, etc.

Educational opportunities. As listed in the course descriptions for the Department of Chemical Engineering, the faculty of the BioProcessing Institute conduct a variety of courses as part of the graduate education curriculum in biochemical engineering. The typical graduate level biochemical engineering curriculum would also include core courses in chemical engineering and basic science courses in microbiology, biochemistry and molecular genetics offered through the departments of biology and chemistry.

For more information, write to Janice A. Phillips, Director, BioProcessing Institute, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Building and Architectural Technology Institute

BATI is concerned with the entire scope of the built urban environment, the social, and the cultural aspects of building technology. BATI researchers and faculty carry out border-crossing studies aimed at the development of enhanced livability of the urban environment and its structures, their suitability to the environment for which they are planned, mutations in urban function and conditions, and the concurrent architectural, urban planning, and design problems.

The institute provides a center for interdisciplinary study, research activity, information dissemination, and stimulation for the use of new information in design. BATI has as its goal both the enhancement of academic knowledge through academic research and the practical solution of current physical problems through applied research.

A forum for faculty discussion. BATI provides a forum for faculty discussion, not only from the different disciplines on the campus as they relate to the built environment (architecture, history, sociology, psychology, business, and economics), but also for visiting fellows and professors. It also provides a contact between the academic and the business worlds.

Research. The institute provides the opportunity to identify research problems, develop proposals, and seek mechanisms for their solution. This can include the traditional single-discipline approach, but typically it involves work across the disciplines within the university and with other academic and commercial entities.

Study opportunities. The resources of the institute, the Council on Tall Buildings and Urban Habitat, and other related centers at Lehigh University are available to interested scholars.

For more information write to Dr. Tom F. Peters, Director, Building and Architectural Technology Institute, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015-3007.

Center for Innovation Management Studies

The Center for Innovation Management Studies (CIMS) was established in 1984, in response to the needs of industrial executives and government officials for a university-based center to study the management of research and development and technological innovation.

The center's research program is interdisciplinary and involves research associates from several other universities. The center supports studies of the industrial innovation process, encourages publication in the professional literature, and trains students and business executives for technology management responsibilities through regular course offerings and continuing education programs.

The goal of this research is to enhance the contribution of technology to corporate performance and national productivity through an improved understanding of the technological innovation process and its management.

Under the direction of Alden S. Bean, Kenan Professor of Management and Technology and former director of the division of policy research and analysis at the National Science Foundation, the center is sponsored by 10 corporations, and NSF.

For more information, write to Alden S. Bean, director, Center for Innovation Management Studies, 621 Taylor Street, Rauch Business Center, Lehigh University, Bethlehem, Pa. 18015, or call (215) 758-3427.

Center for International Studies

Formed in 1986, the Center for International Studies develops, supports, administers and coordinates internationally oriented programs and activities throughout the University.

The center was established to strengthen the international dimension of Lehigh University by opening new opportunities for students to study and work abroad; by encouraging and supporting international studies activities on campus; and by stimulating and supporting research in international affairs. The center offers programs in East Asian Studies, International Political Economy, Latin American Studies, and Russian Studies. In cooperation with the department of international relations, the center organizes the annual Cohen International Lecture Series which was made possible by an endowment established by Bertha and Bernard Cohen ('36). The center also sponsors seminars and guest lectures on international topics.

The center is run by an executive committee representing the university's major international studies programs. For more information, write to Donald D. Barry, director, Center for International Studies, Lehigh University, 537A Maginnes Hal #9, Bethlehem, Pa. 18015. (215) 758-4745. For information on study abroad opportunities, contact Karen Keim, Study Abroad Coordinator, 9 W. Packer Avenue, Bethlehem, PA 18015. (215) 758-3351.

Center for Manufacturing Systems Engineering

The Center for Manufacturing Systems Engineering aims to catalyze, coordinate, develop and focus university activities associated with manufacturing. The Center is the focal point for manufacturing-related activities involving graduate education and research. It facilitates the development of knowledge of manufacturing sciences, systems and technologies and promotes the transfer of this knowledge to industry for practical application. The Center uses close ties with industry to ensure that classroom instruction is current, and that research goals are compatible with the long-range needs of industry. It is essential to maintain free flow of ideas

and technology transfer both from research laboratories into industry, and from industry into the classroom. The Center works with an Industrial Advisory Board comprised of member firms in order to accomplish these goals.

The Center has four major thrusts:

1. A Graduate Program which offers a tightly focused one year curriculum leading to the Master of Science degree in MSE, with a "part-time" option.
2. Research directed at solving problems of manufacturing; this also serves to maintain faculty currency and provides a vehicle for student project or thesis studies.
3. Technology transfer to sustain the free flows of knowledge from the research laboratories out to industrial applications, and in the reverse direction from leading-edge member industries back into the classrooms.
4. The provision of services by offering clinics, workshops and other means for communicating and demonstrating the advantages of sound manufacturing systems engineering practice.

As a corollary to these activities the Center is assisting in the development of associated educational, and research programs in Industrial Engineering, Materials Science, Product Design, and Technology Management, at both the undergraduate and graduate levels.

Representatives appointed by subscribing member firms attend twice yearly meetings of the Industrial Advisory Board (IAB), and enjoy opportunities to serve on committees advising on research priorities, curriculum development, funding allocations, technology transfer (Conferences, clinics, seminars, plant visits and workshops), student recruiting and hiring. The Center manages a database comprising faculty research interests, the research priorities and needs of member firms and matches names of engineering contact points in industry.

Research activity. It is a basic thesis that "manufacturing" consists of any activity whereby materials and information are transformed into goods or services for the satisfaction of human needs; furthermore it is the purpose of manufacturing systems to generate wealth. The components of a manufacturing system can be enumerated simply as consisting of materials, processes, equipment, facilities, logistics and people. A manufacturing system is viewed as a complete system which embraces all the activities involved in developing an idea from concept out to the realization of a product (or service) which generates customer satisfaction and revenues, through to end-of-life. Manufacturing systems engineering involves the study, research and development of knowledge of the interactions between the various components as they are combined to generate products with revenues for the sponsoring enterprises and prosperity for the associated communities and stakeholders.

The Center supports faculty research in manufacturing systems engineering topics by means of equipment grants, funding, and the provision of research assistants. Several specific areas receive focus, priorities are reviewed regularly so as to reflect the interests of industry. Some Center activities have relationship to the concerns and needs of electronics manufacturing. This research covers a wide range from theoretical modeling/simulation work out to studying the manufacturing systems aspects of presenting electronic functionality in a variety of alternative modes of packaging, or delivery systems. Another thrust is to gain an understanding of the impacts on the manufacturing system of substitutions or use of alternatives in choices of materials, processes, and equipment for implementation of a design. Additionally, there are investigations into injection molding, activity based costing, areas of design management, tooling and systems research in the Manufacturing Technology Labs, and a project examining the use of Hypermedia for manufacturing education/training applications. The Center also undertakes research liaison projects for industry, these have included such topics as manufacturing planning and software development. There is particular interest in the development of intelligent process diagnostic techniques and their application to small and medium sized enterprises (SME's). The Center supports activities of various university laboratories engaged in studies relating to

manufacturing systems, however, the Center does not operate any laboratories.

There is collaboration with other Centers, Departments and Laboratories in the preparation and planning of research proposals and programs which aim to improve the understanding of manufacturing.

Educational opportunities. A predominant CMSE activity is a cross-disciplinary graduate program leading to an MS in MSE degree in the College of Engineering and Applied Sciences. This program includes courses delivered by faculty from the College of Business and Economics, it commenced in 1984 as result of a major initiation grant from the IBM Corporation. Since inception over 249 students have passed through this integrated offering which comprises several notable features including teaming activities and courses taught by members of several different departments.

A partial-release program utilizing the same "managed" curriculum is available for employees of Lehigh Valley and neighboring industries, there are separate classes requiring four semesters of one evening and one day per week attendance plus an industrial research project.

Admission to educational programs administered in association with the Center is achieved by application through the Graduate School and the department of the appropriate engineering discipline. The Center is NOT a department and graduate students come under the department of whichever discipline happens to be appropriate, and must meet the standards required by that department. Candidates who wish to pursue a doctorate focused on aspects of MSE must apply for entry to the Ph.D. program of the department of their choice. The Center may, or may not, choose to be associated with the support of the research goals of such doctoral candidates.

For more information, write to: Keith M. Gardiner, Director, Center for Manufacturing Systems Engineering, Lehigh University, 200 W. Packer Avenue, H.S. Mohler Laboratory, Bethlehem, Pa. 18015, or call (215) 758-5157.

Center for Molecular Bioscience and Biotechnology

The Center for Molecular Bioscience and Biotechnology represents part of Lehigh University's commitment to an environment that promotes interdisciplinary research and training opportunities. By bringing together faculty, graduate students, and support staff with backgrounds in biochemistry, biochemical engineering, molecular biology, and the neurosciences in a single state-of-the-art laboratory facility, the center fosters collaborations among faculty, students, biotechnology companies, and health care providers that will lead to advances in product development, production techniques, diagnostic tools, and treatment delivery systems.

The center is one of the best-equipped basic and applied biotechnology facilities in the country. Consisting of over 45,000 square ft. of laboratory and office space, it contains core facilities (for example, for DNA synthesis, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, etc.), individual biochemistry and molecular biology labs, and a pilot plant with a range of fermentation process capabilities.

The financial mainstay of the center is standard contract research from government funding agencies and private companies. In addition, the CMBB Liaison Program encourages private companies to maintain strong ties with the university by supporting, through a single program, proprietary research and nonproprietary fundamental research of general interest. Through the program, member companies gain access to university resources, stay in touch with the current basic research, and have the opportunity to work directly with faculty and students on projects of mutual interest. Center faculty and their students benefit by keeping aware of the latest developments and needs of the private sector.

Research activities. Current interests within each of the cognate disciplines are: *Biochemistry:* Structure and function of glycoproteins and proteoglycans in normal and diseased

tissues, lysosomal enzyme structure and function, eukaryotic DNA structure and nucleosome formation, the use of porphyrins for the diagnosis and treatment of malignancies, preparation of radiopharmaceuticals with high target-tissue specificity, synthesis of therapeutic drug candidates, development of non-isotopic immunoassays, and kinetic and thermodynamic aspects of protein binding surfaces.

Biochemical Engineering: Research interests encompass several aspects of bioprocessing with emphasis on bioseparations using adsorption and aqueous two phase systems, chromatographic modeling, bioreactor instrumentation and control, and the development of strategies for cultivating mammalian and microbial cells. *Molecular Biology:* Structural/functional analysis of fundamental cyto-skeletal filaments, tissue-specific gene expression and protein function during development, plant cell molecular genetics, heterologous gene expression, RNA processing and ribonucleoprotein transport, and translation control, diagnosis and treatment of sexually-transmitted human papillomaviruses and other microbial infections, quantitative detection of lipoprotein and hormone receptors, and specific antibodies for immuno-contraception and immunotherapy. *Neuroscience:* Neurochemical, neuroendocrinological, and neuroanatomical systems regulating processes such as the relationship between metabolic function and fertility, chemocommunication, aggression, and reproductive behavior, biochemical and molecular biological research on cellular regulation of food intake and steroidal regulation of gene expression, development of clonal neural cell lines, biochemistry and pharmacology of excitotoxicity, and the production of novel monoclonal antibodies for the detection of steroids and receptor proteins.

Educational opportunities. The center welcomes graduate and undergraduate students from any academic department to engage in degree or nondegree-related research under the direction of faculty associated with the center. Activities and facilities are diverse and flexible to meet the needs of any student interested in various aspects of biotechnology ranging from basic microbiology and biochemistry to engineering design. Regardless of a student's specific goals, he or she will be immersed in a rich and stimulating environment where there is a high level of intellectual camaraderie and cooperative activity.

Graduate students doing Ph.D. dissertation research in the center receive degrees from existing academic departments. Generally, the student's adviser will be a center associate, although he or she may not be from the student's own department, which affords the student great flexibility in choosing a research area. Also, the close associations within the center make it easy for the student to obtain guidance from several faculty experts.

The center sponsors an active seminar schedule that includes prominent speakers from around the world. It also emphasizes presentations made by faculty and students associated with the center.

Continuing education is another important activity of the center. This component includes, but is not limited to, short courses of various degrees of specificity as well as practical training programs dealing with subjects ranging from basic laboratory skills to the operation of large, computer-coupled fermentors.

For more information about the center's activities and financial assistance for graduate students, write to Neal G. Simon, director, Center for Molecular Bioscience and Biotechnology, Iacocca Hall, 111 Research Drive, Lehigh University, Bethlehem, Pa. 18015.

Center for Polymer Science and Engineering

The Center for Polymer Science and Engineering (CPSE) was formally established at Lehigh University in July 1988. The Center provides a unique opportunity for faculty and students from the traditional departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering and mechanics, and physics to perform interdisciplinary research in polymers. The Center

is an umbrella organization encompassing polymers research and graduate studies at Lehigh University. The Center's primary missions are preparation of first rate scientists and engineers with proficiency in polymers; fostering cross-disciplinary polymer research; and organizing and teaching continuing education short courses in areas of interest to the polymer industry; and organizing campus wide seminars.

The Center's Polymer Education Committee graduate studies through the academic departments leading to the Master of Science and Doctor of Philosophy in Polymer Science and Engineering. Students may also elect to pursue studies towards a classical degree in their respective departments with an emphasis in polymer courses and research. Both advanced undergraduate and graduate courses in polymer science and engineering are offered through the participating departments. Current course offerings include polymer synthesis and characterization, physical polymer science and organic polymer science, engineering behavior of polymers, rheology, polymer processing, emulsion polymers, biopolymers, polymer blends and composites, fatigue and fracture of engineering materials, and colloid science.

Research activities. The center has a wide range of research activities covering the field of polymers. The following are the major research themes: Surface/interfacial aspects of polymer colloids, adhesion, and polymer blends and composites; polymerization mechanisms and kinetics; polymerization reactors modeling and control; structure/properties relationship of interpenetrating polymer networks; macromolecular chemistry of biopolymers and coal; polymer coatings for corrosion protection, microelectronic packaging.

Research facilities. The following research instrumentation are available for the Center for Polymer Science and Engineering: X-Ray Photoelectric Spectroscopy (ESCA), Scanning Auger Electron Spectroscopy, Laser Raman Spectroscopy, Mossbauer Spectroscopy, Nuclear Magnetic Resonance Spectroscopy of both solids and solutions (NMR) (3 instruments; 90 MHz, 300 MHz and 500 MHz), Fourier Transform Infrared Spectroscopy (FTIR) (both conventional and photo-acoustic), a variety of advanced transmission and scanning electron microscopes, several calorimetry devices, instruments for rheological studies (including a Weissenberg Rheogoniometer and Bohlin Rheometer), particle sizing instruments (Coulter N4M, Joyce-Loebl Disc Centrifuge, Capillary Hydrodynamic Fractionation, and Hydrodynamic Chromatography), Gel Permeation and Gas Chromatography units, Electrophoretic Mobility apparatus, mechanical testing devices such as the Rheovibron Dynamic Mechanical Spectroscopy, Instron Tensile Test equipment, several computer-controlled servohydraulic fatigue test machines, and Polymerization Reactors, including Bottle Polymerizer, Tubular Reactor, Stirred Tank Reactors with on-line sample analysis for residual monomer and interfaced with computer for control operations.

Educational opportunities. Programs of study for individual students are designed to meet the student's interests, the requirements of the academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic. Lehigh University has been awarding interdisciplinary M.S. and Ph.D. degrees in Polymer Science and Engineering since 1975. Graduate students conducting polymer research may also earn the M.S. and Ph.D. degrees in the classical fields of chemistry, chemical engineering, materials science and engineering, physics, or mechanical engineering and mechanics. For further information please refer to the Polymer Science and Engineering Program in the section: Interdisciplinary Graduate Programs.

For more information about the center activities, admission to graduate school, or financial aid, contact; Dr. Mohamed S. El-Aasser, Director; Center for Polymer Science and Engineering, 111 Research Drive, Iacocca Hall, Room D330, Lehigh University, Bethlehem, PA 18015; (215) 758-3590.

Center for Social Research

The Center for Social Research is a multidisciplinary organization designed to stimulate and conduct research involving the social and behavioral sciences.

Several disciplines are involved in the activities of the center: psychology, sociology, anthropology, marketing, and political science. The center also cooperates with the university's other research centers and with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened, and the name changed to the Center for Business, Economics and Urban Studies. The center's early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center's scope to encompass the disciplines of political science, sociology, and history. In 1972, the center's scope was further broadened to include behavioral science and international affairs, and the present name was selected to more accurately reflect this broadened focus.

Interdisciplinary research. The social perspective of the center's research is interdisciplinary in nature and is relevant to the community outside the university—local, regional, national, and international. Many research activities are based on a cooperative university-community relationship through which the research goals of the center are achieved and community needs met. Interdisciplinary research activities of the center are currently being conducted in the following areas:

Health and Human Development. Members of the departments of psychology, sociology/anthropology, government, and education, participate in research on health and human development. The program focuses on life from early childhood to maturity. Research interests include the effect of perinatal loss on families and family members; the influence of family and community on health; management aspects of organizations that serve elderly individuals; public and private pension systems; psychological aspects of aging; design of housing for the older adult, and psychological aspects of late life physical disabilities such as stroke and amputation.

Recently completed projects have examined relationships between apportionment of service agency budgets and agency managerial objectives, inclusion of older adults in college courses, reactions of long-term residents to neighborhood change, and a study of cognitive functioning in the later years.

Families and Children. Members of the departments of government, psychology, sociology/anthropology, and economics participate in studies pertaining to families and children. Research interests include family dynamics and child rearing practices and the emphasis on families included under the health and human development program, particularly the influence of community organization and dynamics on the health of residents. Current research focuses on the effect of child rearing practices on children's development of competence.

Program evaluation. Members of the departments of psychology, sociology/anthropology, and economics, participate in research to evaluate the effects of a variety of programs. Particular emphasis is on improving program evaluation methodology. Current research interests include evaluation of several business, science and engineering programs in the university. Research has recently been conducted on the effect of compensatory education programs.

Educational opportunities. Master's and doctoral-level degrees are offered through the departments with which CSR cooperates. An interdisciplinary doctoral program in applied social research is offered jointly by the departments of psychology, government and sociology/anthropology in the College of Arts and Science, by the College of Business and Economics, by the College of Education, and by the Center for Social Research. This program emphasizes training in research methodology relevant in nonacademic settings (see description under Interdisciplinary Graduate Programs).

For more information, write to Diane Hyland, director, Center for Social Research, 516-520 Brodhead Ave., Lehigh University, Bethlehem, Pa. 18015.

Chemical Process Modeling and Control Research Center

The Chemical Process Modeling and Control Research Center (PMC) is a university-industry cooperative research center performing innovative generic and applied research that addresses the chemical processing industry's needs. Founded in 1985, the center is funded by the National Science Foundation and through the membership fees of a consortium of industrial companies.

Fifteen faculty members collaborate in the research and teaching responsibilities of the center. They bring expertise from academic disciplines such as chemical, mechanical, industrial and electrical engineering, and diverse research areas such as polymer reaction engineering and biotechnology.

Prior to the establishment of the center, Lehigh faculty members, in collaboration with industrial representatives, assessed the research needs in the area of process modeling and control. This assessment recognized that rapid technological advances are driving engineering toward cross disciplinary interactions. It identified several trends that have already affected and will continue to affect the chemical, petroleum, petrochemical and biochemical industries in the next decade. These trends have generated the need for an intensified research effort in chemical process modeling and control. They define the research mission of the center.

Membership fees support generic research that focuses on advanced, practical methods and tools that are pertinent to several processing problems. Examples of problems of interest to the center are: effective multivariable process control techniques; distillation control; batch reactor control; reactor modeling; process simulation; statistical process control; and plant-wide control. Member companies often propose new research problems for the consideration of the center's faculty. Their suggestions help define the generic research activities of the center and ensure that the center's research is aimed at solving a class of significant industrial problems.

Research activities. More than ten generic research projects have been initiated as active projects. These projects, representing major research challenges, are as follows: nonlinear control structures for chemical reactors; design of practical multivariable process controllers; design and control of energy-efficient distillation column systems; modeling and control of bioreactors; monitoring and control of emulsion copolymerization; plant-wide control; batch reactor control; statistical process control; nonlinear identification.

Some of the other research and educational activities of the center include week-long short courses in a wide range of areas; progress reports of the research activities that are released to member companies twice a year; an exchange program in which industrial researchers come to Lehigh University to participate in the research program; and the development of specific contractual research arrangements between member or nonmember firms and center faculty members.

Educational opportunities. Due to its special character and mission, the PMC Research Center offers unique educational opportunities to students who wish to receive a graduate degree with research specialization in the area of process modeling and control. In recognition of the growing need for an engineering education that cuts across the engineering subdisciplines, the center actively involves faculty and students with varied backgrounds and expertise. Furthermore, with its research and educational activities, the center aims at lessening one of the primary weaknesses in present-day engineering education, namely, the understanding of how engineering knowledge is converted by industry into social goods and services. This goal is served by the center's generic and, by its applied research activities and by a comprehensive series of graduate and

undergraduate courses, invited industrial and academic speakers, and group meetings and seminars.

All Lehigh University control courses are coordinated and cross listed between the departments of chemical, mechanical, and electrical engineering. Group meetings and seminars are used as a mechanism for the increased transfer of information and ideas among center graduate students and industrial researchers from the member firms. Distinguished academic and industrial researchers, in the areas of process modeling and control, are invited to Lehigh for extended series of lectures and in-depth discussions of current research topics.

To make undergraduate students more aware of the challenges and rewards of research, the center offers them opportunities to participate with graduate students in research. This provides graduate students with an opportunity to be a researcher and a teacher/supervisor at the same time.

For additional information about the center, contact Christos Georgakis, director, Center for Chemical Process Modeling and Control, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015-4791, (215) 758-4781.

Diamond Center for Economic Education

The Center for Economic Education was established in 1976. It is part of a nationwide network of more than 270 such centers under the guidance of the EconomicsAmerica-National Council on Economic Education. It is also one of 12 Centers in the statewide network affiliated with the EconomicsAmerica-Pennsylvania Council on Economic Education.

For more than a quarter of a century, the Joint Council has been involved in programs to reduce the level of economic illiteracy in the United States. The purpose of Lehigh's center is to increase the quantity and improve the quality of economic education.

Located in the Rauch Business Center, the center is part of the College of Business and Economics. But it takes on an interdepartmental role as it coordinates programs aimed at heightening understanding of the American business and economic system. The center also serves as a clearing house for educational ideas. It also houses an expanding resource library including books, videos, curriculum material, testing packets, and simulation games for use by faculty and area educators.

Educational opportunities. The center sponsors workshops, seminars and guest lectures designed to meet the educational needs of faculty and students. Activities and projects, such as the Stock Market Game simulation, allow teachers and students the opportunity to experience the workings of the market and the free enterprise system.

For more information, write to the center's director, Warren A. Pillsbury, Diamond Center for Economic Education, Rauch Business Center, 621 Taylor Street, Lehigh University, Bethlehem, PA 18015.

Emulsion Polymers Institute

The Emulsion Polymers Institute, established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s.

The institute has close ties with polymer and surface scientists in the Center for Polymer Science and Engineering, Polymer Interfaces Center, Zettlemoyer Center for Surface Studies and the Materials Research Center, Center for Chemical Process Modeling and Control, and the departments of chemical engineering, chemistry, physics, and material science and engineering.

Polymer colloids or polymer latexes, as they are more commonly called, are finely divided polymer particles that are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings.

The small particle size of typical latexes make their colloid properties as important as the polymer properties for a number of applications. Hence, the study of emulsion polymers is an interdisciplinary activity.

Research activities. Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients; some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of recipe components during preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental problems: emulsion polymerization kinetics, mechanism and morphology of core/shell latexes, colloidal surface and bulk properties of polymer colloids, dispersion polymerization, mechanism and kinetics of inverse emulsion polymerization, miniemulsions, alkali-swelling behavior of carboxylated latexes, inverse suspension polymerization, NMR studies of polymer colloids, electrophoresis of polymer colloids, coating by electrodeposition, and associative thickeners.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerable effort is made to relate the research results to industrial needs. Consequently, graduates can find excellent opportunities for employment.

Educational opportunities. Graduate students in the institute undertake dissertation research leading to the master of science or doctor of philosophy degrees in existing science and engineering curricula or in the center for polymer science and engineering.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, *Advances in Emulsion Polymerization and Latex Technology*, typically attracts about 100 industrial participants and 20 Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers. Educational and research opportunities exist for postdoctoral students and visiting scientists as well as resident graduate students.

For more information, write to Mohamed S. El-Aasser, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.

Energy Research Center

Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and economics, and the social sciences. The Energy Research Center provides a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, the center was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress—supported by contracts and grants from government, industry, and private foundations—deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and government

facilities have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies and other projects related to energy. Through the center's Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, fluid mechanics, surface chemistry, chemical kinetics, GC/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, hydraulics and water resources, van de Graaff accelerator, biotechnology, aquatic biology, and microprocessor development.

All faculty members who participate in Energy Research Center activities belong to academic departments. In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers and institutes, assuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and biotechnology.

Energy research. Research within the center falls within five major categories. Projects of interest include:

Fossil fuels. Fluidized bed combustion of coal; heat transfer in fluidized beds; pulverized coal combustion; catalytic combustion; cyclonic combustion; coal slagging; freezing of coal; coal chemistry; microbial desulfurization of coal; kinetics of coal gasification; fluidized bed gasification; dynamic simulation of coal conversion systems; kinetics of coal liquefaction; hydrogen-enhanced crack growth in high-strength steels; organic coatings for flue gas desulfurization service; weld repair of steam turbine rotors; mechanical properties of cryogenic steels for LNG applications; toughness of pipeline steels; fracture analysis of pipelines; mechanisms of tertiary oil recovery.

Nuclear technology. Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; microstructural characterization of pressure vessel welds; pressure vessel design, radioactive waste disposal; high-energy particle physics, nuclear physics.

Environmental impact of energy systems. Oil pollution studies in the coastal and wetlands environment; effects of power plant operations on biological life in the New Jersey estuarine region; acid rain; trace metal contamination of aquatic ecosystems; hazardous waste disposal and control.

Conservation and renewable resources. Biological conversion of cellulose to chemicals and fuels; catalysis for alcohols from biomass; energy recovery from municipal solid waste; fuel derived from waste water treatment; energy conservation in the metal-forming industries; instrumentation and analysis of industrial processes; use of computers for process control; development of microprocessors for residential load control; cooling of electric utility generators and high-capacity electric motors; design of cryogenic turbines; instrumentation for HVAC applications; siting of wind-power applications.

Energy economics. Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; peak-load pricing of electricity and natural gas.

Educational Opportunities. The extensive involvement of faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Applied Sciences, as well as several departments within the College of Arts and Science and the College of Business and Economics, are active in energy research and offer both

masters and doctoral degree programs suitable for studies of energy-related topics.

All degrees are granted by the academic departments and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by complementing their programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry through a program in which a graduate student involved in energy can do a research internship in industry under the joint supervision of the company research staff and the student's faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and research assistantships related to sponsored research.

Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, public policy and nuclear power, air pollution, coal catalysis, coal technology, materials for modern energy systems and solar energy.

The Energy Research Center also sponsors an annual seminar series, bringing some of the outstanding people in the energy fields to the campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of new developments in energy.

For more information, write to Edward K. Levy, director, Energy Research Center, Lehigh University, 117 ATLSS Drive, Bethlehem, Pa. 18015.

Engineering Research Center For Advanced Technology For Large Structural Systems (ATLSS)

The ATLSS Engineering Research Center was established in May 1986 with a grant from the National Science Foundation (NSF) to serve as a national focal point for research and technology aiding structures-related industries. In 1991, the Center added a major program directed to the shipbuilding industry and related to advanced materials and hull designs for U.S. Navy and commercial fleets-of-the-future. Currently, about 110 persons, including graduate and undergraduate students, research associates, faculty and staff members representing the disciplines important to large structural systems are active in research at the Center.

The research program at ATLSS is cross-disciplinary and broad in scope. Research topics include Materials, Connections, and Processes; Design and Construction Information Systems; Sensing and Infrastructure Assessment; Integrated Building Systems; and Assessment of Competitiveness Factors.

The projects within these research clusters follow the structural system life-cycle processes of experimentation, design, fabrication and construction, and operation. The ATLSS research studies are conducted in close association with advisory committees of engineers and scientists from industry, government, design and professional groups and other universities.

ATLSS has excellent research facilities and equipment, including the structural testing facilities of the Fritz Engineering Laboratory, and the major new (1989) world-class large-scale multidirectional loading facility known as the ATLSS Laboratory in which researchers evaluate large complex connections, assemblages and structures under static and/or cyclic loading. The new facility enables complete computer-controlled experimentation. ATLSS

also has outstanding computer resources, and a fine mechanical testing, welding, metallography, and non-destructive evaluation complex.

Research Activities:

High-Performance Materials—Research is conducted on new structural forms and structural systems to promote competitive use of new materials. High-performance steel, concrete, fiber-composite, and mixed systems are included.

Connection Design Methodologies—an integrated effort to advance connection technology in construction and to establish a connection design methodology. A new system of connections, called ATLSS connections, has been developed to attain an optimum combination of load capacity, fabricability, and erection automation.

Construction Automation—the application of automation to the construction environment for a variety of tasks, such as building erection, water-jet cutting, welding and connection techniques, and inspection. The use of sensor-equipped computer-controlled crane platforms is the focal point of effort in this area.

Design and Construction Information Systems—the development of real-time decision support systems. Current examples include an intelligence interface that will enable designers and fabricators to collaborate efficiently in evaluating design alternatives and making fabrication decisions for construction projects; and a knowledge-based bridge fatigue investigator system to guide an engineer through a bridge inspection, to shorten the inspection time, enhance the quality of the inspection, and assess fatigue and fracture damage.

Performance Assessment of Structures—the development of smart monitoring systems; new intelligent sensors as well as new applications for non-traditional sensors in monitoring structural performance. The studies have resulted in new sensors for corrosion monitoring, and studies are proceeding using sensors based on acoustic emission, fiber optic, vibration, and coating principles.

Fleet of the Future Programs—These programs study new designs, new materials, and new manufacturing systems for future combatant ships of the U.S. Navy and for commercial oil tankers. The emphasis is on advanced double-hull designs with modern high performance steels. Proof-of-principle testing in the ATLSS laboratories is used to assess the new concepts.

Educational Opportunities. The ATLSS Center facilitates programs of study and research that cross the traditional boundaries of engineering curricula, providing a fundamental, broad approach to the field of structures.

Graduate students participating in the Center's program usually receive master of science, master of engineering, or doctor of philosophy degrees in the academic discipline of their choice, i.e., civil engineering, material science and engineering, computer science, industrial engineering, mechanical engineering, etc. However, they are expected to pursue course work related to a broader understanding of structures and to conduct research on a cross-disciplinary problem in the Center.

Financial support for graduate students is available through the ATLSS Research Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates also participate in the Center's research and educational program. Opportunities for summer internships and for academic-year special projects are available which enable direct involvement in the Center's research effort.

For more information, write to the director, Dr. John W. Fisher, 117 ATLSS Drive, Lehigh University, Bethlehem, PA 18015-4729.

Health Sciences Institute

The Health Sciences Institute, organized in 1972, is concerned with interdisciplinary research and graduate and postdoctoral training in various aspects of the biomedical sciences and engineering.

A large part of the research conducted at the center is supported by private and public agencies and all are related

to either basic or applied aspects of problems pertaining to human and animal life.

Research activities. Interests currently represented among faculty members include the following: immunochemistry applied to clinical diagnostics, modification and use of monoclonal antibodies in radiosensitization and NMR imaging, surface adhesion in biological systems, glycoprotein structure and function, cell-cell interactive proteins, tumor image enhancement, medicinal chemistry, neuroendocrinology, motility and behavior of cells, chemistry of biologically potent molecules, manipulation of bacterial genetics, and recombinant DNA biotechnology.

The administrative offices and most of the laboratories are housed in Iacocca Hall of the MTC. The laboratories are well equipped, and the major pieces of equipment include three NMRs, mass spectrometers, numerous liquid and gas chromatographs, tissue culture laboratory, bacterial transfer room, fermentors, warm room, cold rooms, scintillation and gamma counters, UV-Vis and infrared (including Fourier transform) spectrophotometers, ultracentrifuges and ancillary equipment necessary to conduct the above studies.

Ongoing interactions with Hahnemann University, St. Luke's Hospital and Lehigh Valley Hospital Center exist; clinical aspects of several research projects are being conducted there.

Educational opportunities in the Health Sciences

Institute. Graduate students working under the direction of members of various components of the institute may satisfy course requirements towards the M.S. and Ph.D. degrees by selecting from the offerings of the departments of chemistry, physics, molecular biology, psychology, civil engineering, mechanical engineering and mechanics, as well as other departments.

In addition, the interdisciplinary graduate program in physiological chemistry leading to the master of science and the doctor of philosophy degrees is supported by the Health Sciences Institute, although all of these students are enrolled in the department of chemistry. Students may also pursue graduate degrees in biochemistry, organic, clinical chemistry, or molecular biology under supervision of institute faculty members.

In addition to research, the institute sponsors symposia as well as annual series of seminars on topics pertinent to its objectives.

For more information, write to the director, Jack A. Alhadeff, CMBB, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Iacocca Institute

Over the years, Lehigh University has developed and refined an impressive ability to forge university-industry-government partnerships. These partnerships are critical not only to the future of universities, but, also to improving U.S. competitiveness. It is primarily through partnerships—with companies, schools, governments agencies and other universities—that the Iacocca Institute pursues its mission to advance the global competitiveness of U.S. industry. Established with support and guidance from Lee Iacocca '45, the Institute and its partners in industry, government and education have developed four competitiveness program areas: Manufacturing Competitiveness, Educational Competitiveness, Technology Transfer and Policy Study. One of the Institute's key objectives is to aid in enhancing the knowledge and leadership capabilities of both Lehigh students and the business community. To that end, the Agile Manufacturing Enterprise Forum, (AMEF), the Northeast Tier Ben Franklin Technology Center (NET/BFTC), the Manufacturers Resource Center (MRC), and the Small Business Development Center (SBDC), are all organized under the umbrella of the Iacocca Institute. (see separate listing)

Current outreach activities in educational competitiveness include the partnership with Cities in Schools, Inc., and Lehigh's College of Education. Together they develop the National Center for Partnership Development (NCPD) to help stem the dropout crisis in America and improve basic, intermediate and secondary

education throughout the United States. Through the NCPD, training sessions are held at Lehigh to replicate the successful Cities in Schools model across the nation. In addition, the Iacocca Institute helped develop a very successful and popular interdisciplinary undergraduate seminar on competitiveness taught by faculty from each of the three undergraduate colleges as well as key corporate leaders.

The Iacocca Institute was established in 1987 with the support of Lee A. Iacocca, chairman of the executive committee, Chrysler Corporation, and a member of Lehigh's Class of 1945. Mr. Iacocca chairs a distinguished advisory board which provides close ties with industry. Its other members are Dexter F. Baker, '50, MBA, '57, chairman, executive committee, Air Products and Chemicals, Inc.; Douglas A. Fraser, former president, United Auto Workers, University Professor of labor studies, Wayne State University; William C. Hittinger, '44, former executive vice president, research and engineering, RCA Corporation; Drew Lewis, chairman and chief executive officer, Union Pacific; Peter Likins, president, Lehigh University; Thomas J. Murrin, former deputy secretary of Commerce, Dean, A.J. Palumbo School of Business, Duquesne University; John Wells Puth '52, J. W. Puth Associates; David M. Roderick, former chairman and chief executive officer, USX Corp.; Patrick A. Toole, IBM senior vice president, manufacturing & development; Walter F. Williams, chairman and chief executive officer, Bethlehem Steel Corp.

Representatives from each of Lehigh's undergraduate colleges and the graduate-level college of Education serve on the Institute's Program Board. The Review and Prioritization Board (R&P), an outside board made up of representatives of major U.S. industries, meet four times a year to help shape priorities and programs for the Institute.

For more information, write to Dr. Richard W. Barsness, Executive Director, Iacocca Institute, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Institute for Biomedical Engineering and Mathematical Biology

The Institute for Biomedical Engineering and Mathematical Biology was established July 1, 1988 to foster interdisciplinary research and support graduate study in the application of engineering and mathematics to medicine and biology. Faculty from several engineering departments and from mathematics and biology actively participate in the Institute. Current research includes the mathematical analysis of transport and exchange in microcirculatory physiology, theoretical and experimental biomechanics, experimental biofluidmechanics, fracture and failure in skeletal units and in prostheses, shock propagation through the human body, and design for the handicapped.

The Institute has established an extensive network of interaction and generated significant research collaboration with a number of major medical centers. An effective liaison program fosters interaction between the University and industry in the biomedical field.

Graduate students interested in studying biomedical engineering or mathematical biology at Lehigh enroll in one of the engineering departments or in the applied mathematics program, and satisfy the corresponding degree requirements. The Institute provides the opportunity for interdisciplinary research for both the master's thesis and the Ph.D. dissertation.

For further information, write to Eric P. Salathe, Director, Institute for Biomedical Engineering and Mathematical Biology, Chandler-Ullmann Hall, Lehigh University, 17 Memorial Drive, East, Bethlehem, PA 18015.

Institute for Metal Forming

The Institute for Metal Forming, sponsored by the department of materials science and engineering, was established in 1970 to teach the principles and applications of metal-forming technology to graduate and undergraduate students; to provide instruction and

equipment for graduate research in metal-forming processes; and to assist industry with solutions to problems in metal forming.

Metal-working processes are analyzed mathematically, usually involving the computer. The results of the analyses are checked and refined by comparison with experimental data obtained in the fully instrumented metal-forming laboratories that are part of the institute's facilities.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audio-visual techniques in integrating expert systems provided as software for personal-computer users. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

Research activities. Current research areas include: hydrostatic extrusion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on tensile properties; friction modeling and measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and iron rolling; and powder consolidation. Special emphasis is currently being given to fabrication of high-temperature ceramic, super-conducting wire, and to computer simulation of metal forming processes.

Educational opportunities. Students interested in metal forming should refer to course descriptions for metallurgy and materials engineering and mechanics.

For more information, write to the director, Betzalel Avitzur, Whitaker Laboratory, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015.

Institute of Fracture and Solid Mechanics

The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on an interdisciplinary basis. A branch of this Institute was established in the Republic of China in 1987 to carry out cooperative research activities.

An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, environmentally accelerated cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The activities of the institute include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; conducting liaison programs with industry and government agencies.

Research activities. There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and governmental agencies. They include:

Fracture mechanics. Analytical: stress analysis of engineering structures weakened by flaws.

Experimental: static and dynamic fracture toughness testing of metallic, nonmetallic and composite materials.

Solid mechanics. Analytical and numerical methods of analysis.

Plates and shells.

Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, metallurgy and materials engineering, civil engineering, chemistry and biology.

For information, write to the director, George C.M. Sih, Packard Laboratory, Lehigh University, 19 Memorial Drive, West, Bethlehem, Pa. 18015.

Institute of Thermo-Fluid Engineering and Science

The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate the utilization of this interdisciplinary strength in the university's educational programs.

Currently 28 full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, mathematics, and physics are among the institute members. Graduate students and undergraduates as well as part-time and visiting staff members, join in the institute's activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Physical Sciences. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit operations, thermodynamic properties, and reaction engineering. The university's Computing Center as well as various minicomputers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids Liaison Program, to promote the interchange of knowledge between the researchers at Lehigh and the engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute's staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research activities. The institute's staff members are involved in three interrelated areas: fluid mechanics, heat transfer and thermal science, and applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute's current research program includes more than twenty grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, colloid size distributions by hydrodynamic chromatography, fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Physical Sciences. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics. Undergraduates can select a program of study, in consultation with their adviser, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the M.S. or Ph.D. with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate

students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For information regarding the Institute of Thermo-Fluid Engineering and Science, write to the director, John C. Chen, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies was established in 1971, to honor one of America's most distinguished scholars, who served as a long-time member of the faculty at Lehigh. Gipson's monumental life work, *The British Empire Before the American Revolution* (15 volumes) was written between 1936 and 1970. Gipson received the Pulitzer Prize in History in 1962 for Volume 10, subtitled, *The Great War For Empire*. When he died in 1971, Professor Gipson left his entire estate to Lehigh and provided the original endowment for the Institute.

Research activities. The income from the endowment of the Institute is used to encourage faculty and student research in the eighteenth century by providing small grants to defray travel cost, copying and other expenses to permit scholars to visit necessary libraries and depositories, to help support deserving students in their dissertation year and to encourage interdisciplinary research activities at Lehigh. The Institute also helps provide additional resources to build the university library's research collections in eighteenth century studies.

Educational opportunities. The Institute invites leading scholars to give occasional lectures and supports relevant programs such as interdisciplinary seminars and visiting scholars interested in the eighteenth century. Annual symposia honor Professor Gipson by bringing to the campus distinguished scholars in eighteenth-century studies to lecture and discuss various topics. The essays generated at the symposia have been published and the Institute maintains a continuing close relationship with Lehigh Press that also publishes original manuscripts on the eighteenth century.

For further information, write to either of the co-directors, William G. Shade, department of History, Maginnes Hall, 9 W. Packer Ave., or Jan Fergus, department of English, Drown Hall, Lehigh University, 35 Sayre Drive, Bethlehem, PA 18015.

Philip and Muriel Berman Center for Jewish Studies

The Philip and Muriel Berman Center for Jewish Studies, established in 1984, develops, administers, and coordinates programs in Jewish studies among member institutions of the Lehigh Valley Association of Independent Colleges (LVAIC) (Lehigh University, Muhlenberg College, Lafayette College, Moravian College, Cedar Crest College, and Allentown College of St. Francis de Sales). Housed at

Lehigh, the Center for Jewish Studies is directed by Laurence J. Silberstein, Philip and Muriel Berman professor of Jewish Studies. The center supports and encourages shared course offerings as well as the exchange of faculty among LVAIC institutions. Faculty in Jewish Studies, housed at Lafayette College, Lehigh, and Muhlenberg College, are associated with the center. In addition to teaching on their home campuses, these faculty offer Jewish studies courses on other LVAIC campuses each semester. A visiting scholar from Israel is in residence at the center annually and teaches courses at Lehigh and other LVAIC schools.

Activities of the center include designing and implementing new courses and seminars, establishing research grants for undergraduate students, sponsoring study programs abroad for undergraduates, organizing an annual lecture series, and sponsoring colloquia, conferences, and a publication series in Jewish studies. The center coordinates year-long, semester, and summer study programs in Israel at the Hebrew University, Tel Aviv University, and the Tel Mique-Ekron Archaeological Project. For further information on Israel study programs, contact Shirley Ratushny, 758-3352.

Philip and Muriel Berman of Allentown, Pa., in consultation with Judaic scholars from the United States and Israel, conceived of and provided the initial funding for the center. Their goal was to establish in the Lehigh Valley a first-class academic program for the study of all aspects of Jewish civilization. The center customarily opens its programs to the public.

For more information about the Center for Jewish Studies, please contact Dr. Laurence J. Silberstein, 758-4869.

Martindale Center for the Study of Private Enterprise

The Martindale Center for the Study of Private Enterprise was established in 1980 by a gift from Harry and Elizabeth Martindale. The primary purpose of the center is to contribute through scholarship to the advancement of public understanding of the structure and performance of our economic system.

Attention is focused on the private sector of the economy and on public policies as they influence the private sector. To achieve this end, the center activities include the sponsorship of lectures and conferences, support of faculty research and case studies, administration of the visiting scholar and executive-in-residence programs and the publication of two journals, *PERSPECTIVES ON BUSINESS AND ECONOMICS*, and the *LEHIGH REVIEW OF BUSINESS AND ECONOMICS*. The center sponsors and administers the Martindale Students Association Program (for undergraduates) and the Martindale-Rauch Scholars Program (for MBA students). The center has established the Canadian Studies Institute which encourages scholarships dealing with the business and economic environment of Canada and with U.S./Canadian business and economic relations.

For more information, write to the center's director, J. Richard Aronson, Martindale Center for the Study of Private Enterprise, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Materials Research Center

The Materials Research Center was established in 1962. Currently, approximately 140 persons, including graduate students, research associates, and faculty members representing science and engineering departments, are engaged in research pertaining to materials science and engineering.

The fundamental objectives of the Materials Research Center are to encourage interaction among the science and engineering disciplines with an interest in materials and to promote interdisciplinary research activity and interdepartmental educational opportunities. To achieve these objectives, the center seeks to establish a climate in which faculty members, research scientists, postdoctoral associates, and graduate assistants develop an awareness of

materials, arrange for facilities and space required to conduct interdisciplinary research; guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and assist in developing educational opportunities in materials—in particular, interdisciplinary graduate programs devoted to training for research in materials.

The center also conducts the Materials Liaison Program. Founded in 1963, this program promotes the interchange of knowledge between the materials community at Lehigh and engineers and scientists in industry and government. The program conducts seminars on materials research, special lectures and workshops on items of current interest; consults on materials problems and research; distributes master of science and doctor of philosophy theses and abstracts of materials research; and sponsors seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering, and physics. Members of other departments and centers frequently are involved in cooperative programs.

Research Activities. The present organization of the Materials Research Center includes five laboratories: the electron optical, ceramics, thin films and coatings, engineering polymers and mechanical behavior laboratories, located in Whitaker Laboratory. Current interdisciplinary research activities include:

Electron optics. Characterization of fracture surfaces in polymers, ceramics, and steels by scanning electron microscopy; x-ray microanalysis of extraterrestrial materials, ferrous alloys, geological materials and ceramics using the electron probe microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; discontinuous precipitation in non-ferrous alloys; low-temperature phase transformations in iron materials; inclusions in weld structures of ferrous alloys; and glass metal reactions in lunar samples.

Ceramics. Microstructure and solid state chemistry of electronic and electro optic oxides including both polycrystalline and single crystalline materials; degradation mechanisms in ceramic devices; deformation mechanisms, including creep and hot pressing; sintering studies and additive effects; microstructural characterization of ceramic materials; microstructure design of structural ceramics for optimum mechanical behavior.

Defect structure and impurity interactions in insulating, semiconducting, and superconducting oxides in both bulk and thin-film form; interfacial segregation and phase formation in metal-oxide systems.

Mechanical behavior. Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP); test frequency sensitivity and fatigue fracture micromechanisms in polymer solids; metallurgical aspects of FCP in ferrous and non-ferrous alloys; fracture mechanics of functionally gradient materials, fracture mechanism studies by transmission and scanning electron microscopy.

Polymers. Structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; permeability and mechanical behavior of membranes, coatings, and filled polymers.

Thin films and coatings. Thin films of conducting, superconducting, magnetic and insulating materials; coatings for corrosion and wear resistance; processing facilities such as sputtering, plasma enhanced and electro deposition; characterization by electron and optical microscopy, differential calorimetry and x-ray diffraction.

Educational opportunities. This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, materials science and engineering, electrical engineering and computer science, etc.; or in an interdisciplinary program such as polymer science and

engineering. However, they are expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center's five laboratories.

Financial support for graduate students is available through the Materials Research Center by means of research assistantships related to sponsored research programs.

For more information, write to the director, Martin P. Harmer, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015.

The Murray H. Goodman Center for Real Estate Studies

The Murray H. Goodman Center for Real Estate Studies was established in 1988 through a major gift from Murray H. Goodman, '48. The center is a self-supporting, interdisciplinary unit of the College of Business and Economics. The center provides financial support and other assistance for undergraduate courses in real estate and real estate finance, supports scholarly research in real estate, and sponsors joint activities with practitioners in the real estate field.

Educational opportunities. The center provides resources for teaching undergraduate courses in real estate and real estate finance. Sponsored courses include FIN 298 - Introduction to Real Estate and FIN 398 - Real Estate Finance. In addition, the center sponsors a continuing series of seminars and presentations by real estate executives and practitioners. The center also serves as a clearinghouse for students seeking internships with real estate firms and related companies.

Research activities. Consistent with the university's encouragement of scholarly research, the center provides funding for faculty research in the real estate area. Funding possibilities include: summer faculty research grants; travel, telephone and administrative support; and grants for part-time graduate assistants. The center also maintains a file of sponsored research opportunities available through private foundations, government agencies and practitioner organizations and provides administrative support to faculty applying for such funding.

Practitioner Interaction. The third aspect of the center's activities is its interaction with practitioners in the real estate field. The increased emphasis on continuing education and research among real estate practitioner organizations, as well as Lehigh's proximity to major real estate markets, enable the center to engage the practitioner community in a variety of joint projects. These joint projects include: 1. sponsored research projects; 2. continuing education programs and short courses; 3. special conferences and events of national and/or regional interest; and, 4. center-sponsored databases and continuing activities of interest to the practitioner community.

For more information, write to Stephen F. Thode, Director, Murray H. Goodman Center for Real Estate Studies, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015, or call (215) 758-4557.

Musser Center for Entrepreneurship

The Warren V. Musser Center for Entrepreneurship has been established through a generous grant from 'Pete' Musser, Lehigh class of 1949, for the promotion of entrepreneurship among the students and friends of Lehigh University. Mr. Musser, chairman and CEO of Safeguard Scientifics, Inc., is a highly successful entrepreneur in his own right and an active supporter of entrepreneurial ventures by others. Creation of the Musser Center at Lehigh caps more than a decade of university activities dedicated to encouraging and recognizing the role of entrepreneurship in the American business system. The center enables Lehigh to provide new levels of support for the entrepreneurial spirit.

SBDC. The primary activity of the Musser Center for Entrepreneurship is the Small Business Development Center. Established in 1978, the SBDC provides general

management assistance to over one thousand entrepreneurs and small businesses per year in the Lehigh Valley and surrounding areas. Primary funding for this program comes from a major grant from the U.S. Small Business Administration and the Commonwealth of Pennsylvania. The Musser Center provides supplemental support for the efforts of the SBDC and contributes monies to enhance its mission and broaden its scope.

Specialized programs. The International Trade Development Program is a specialized outreach effort of the Small Business Development Center. The ITDP helps companies with exportable products to develop export marketing plans and establish direct contacts with international markets. Seminars, trade missions and research projects support the efforts of this program.

The Government Marketing Assistance Program assists potential suppliers to government in identifying and developing government contracts. Opportunities for marketing to prime contractors are also promoted. Contract administration and general business assistance related to government procedures are handled on a one-to-one basis. Trade fairs and seminars are also offered.

The Financing Assistance Program provides assistance in loan packaging and financial planning and helps clients identify appropriate financing sources. The program administers the Lehigh Valley Small Business Loan Pool. Contracts with the Lehigh/Northampton Revolving Loan Fund, the Bethlehem Economic Development Corporation and other funding agencies provide resources for this assistance.

LUMAC. The Lehigh University Management Assistance Counseling program (a graded three-credit course) was established in 1972 on the initiative of undergraduate students. Through support from the SBDC, approximately one hundred, fifty students per year gain practical experience by providing counseling to sixty businesses.

ACE. The enrichment of entrepreneurship programs at Lehigh is accomplished in part by the Association of Collegiate Entrepreneurs. Through ACE, students meet entrepreneurs and promote new ventures.

LEAP. A related program is the Lehigh Entrepreneurial Associates Program. Leap reaches entrepreneurs currently active in the regional business community. It serves as a forum and educational resource for those interested in extending their entrepreneurial reach.

SCORE. The Service Corps of Retired Executives is another affiliate of the Musser Center. SCORE, which works most closely with the SBDC, is chartered by the U.S. Small Business Administration and provides business expertise to current or potential business owners.

Entrepreneur in residence. The I.U. Entrepreneur in Residence is an active entrepreneur and former CEO of his own multi-million dollar company serving full-time on the staff of the College of Business and Economics. This experienced executive teaches courses on entrepreneurship and counsels students and entrepreneurs on their business plans, management teams and operating activities.

Liaison. Funding from the Musser Center assists other Lehigh University entrepreneurial activities. The Martindale Center for the Study of Private Enterprise uses funding to support student publications. The Center for Economic Education develops curricular materials for secondary school instruction on entrepreneurship. The Musser Center also conducts studies on the problems of business formation and operation and the characteristics of entrepreneurs.

For more information, write to the center's director, John W. Bonge, Musser Center for Entrepreneurship, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015.

The Philip Rauch Center for Business Communications

The Philip Rauch Center for Business Communications was established in 1981 in Lehigh's College of Business and Economics in response to a growing need for more effective communication in business. The Center was established with a gift from Philip Rauch '33, who is a retired chairman of the board of Parker Hannifin Corporation.

The center's mission is to help students develop the skills needed to write effective professional memos, letters and reports, and make successful oral presentations.

In support of the Undergraduate Writing Requirement Program in the College of Business and Economics, the Center's staff collaborates with CBE faculty from all academic areas to reinforce and improve student writing skills. The Center also operates a Business Writing Clinic which invites students to drop by any time during business hours for counseling on writing projects. Established through a grant from the General Electric Foundation, the Clinic is staffed by graduate students who have worked in industry and have demonstrated writing excellence in business communication classes.

The Center works closely with the business community through several programs that offer students a first-hand view of corporate communication activities. Its Executive in Residence program brings to campus industry leaders who espouse the importance of corporate communication. The Center also conducts communication seminars for managers and professionals in a wide range of fields, from business and government to health care and education.

For more information, write Richard W. Barsness, acting director, Center for Business Communications, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Polymer Interfaces Center

The Polymer Interfaces Center (PIC) is an Industry/University Cooperative Research Center that was established at Lehigh University in 1991. It is sponsored by the National Science Foundation (NSF) and is one of approximately fifty centers that have been established at universities throughout the U.S. in an effort to leverage industrial development with university science. In this arrangement, university professors, research scientists and graduate students conduct industrially relevant fundamental research while member companies and the NSF provide operating funds and guidance on the kinds of model polymers, model substrates and goals that are of interest to them.

PIC aims to develop a molecular-level understanding of the structural, dynamic, kinetic and energetic characteristics of the interphase region between polymers and substrates while also developing versatile methodologies to characterize the interphase region. Center research addresses such topics as adsorption, desorption, dynamic wetting, adhesion, charge transfer, transport, miscibility, compatibility and mechanical behavior. The Center's ultimate goal is to generate a scientific database to assist in designing advanced polymers for such diverse applications as lubricants, water treatment, secondary oil recovery, coatings, inks, adhesives, and engineering plastics.

Research activities. The Center is interdisciplinary and includes faculty from five academic departments; chemical engineering, chemistry, materials science and engineering, mechanical engineering and mechanics, and physics. Research scientists from two research institutes at Lehigh University also participate in the Center's research. The current research effort is divided into three theme areas:

- Polymer adsorption/characterization. Investigators are elucidating the processes of associative polymer (hydrophobically modified water-soluble polymer) adsorption and desorption from water onto colloidal and planar surfaces such as polystyrene, TiO_2 and silica.
- Wetting/adhesion. Using industrially important metal and plastic surfaces, researchers in this area investigate the fundamentals of wetting and adhesion and the means of varying these processes by altering the molecular structure at the interface.
- Mechanical behavior of polymer systems. PIC researchers examine the mechanical behavior of polymer systems that innately contain interphase regions or are purposely modified to incorporate interphases. Selected projects include investigations of film formation, properties associated with films derived from thermoplastic and cross-linkable latexes, and "toughening" mechanisms and fatigue resistance in plastics that are modified with rubbery and/or glassy inclusions.

Research facilities. Instrumentation available to PIC includes X-Ray Photoelectron Spectroscopy, Scanning Auger Electron Spectroscopy, Laser Raman Spectroscopy, Fourier Transform Infrared Spectroscopy, Attenuated Total Reflectance Infrared Spectroscopy, Dynamic Light Scattering, Total Internal Reflectance Fluorescence, Ellipsometry, Microcalorimetry, Moire Interferometry, Scanning Electron Microscopy, Transmission Electron Microscopy, Solid-State and Liquid-State Nuclear Magnetic Resonance Spectroscopy, Column Impregnation Units, Serum Replacement Cells and a variety of Mechanical Property Test Equipment. The Center also recently received an NSF equipment grant to acquire an Atomic Force Microscope and the Surface Forces Apparatus.

Educational opportunities. PIC supports graduate-level research for M.S. and Ph.D. degree students in subjects related to the Center's goals. Students receive degrees from their respective academic departments, but they also take special courses on polymer interfaces given by the Center faculty and participate in the multidisciplinary activities of the Center.

For more information, write to Mohamed S. El-Aasser, Center Director, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem PA 18015; (215) 758-3590.

Sherman Fairchild Center for Solid-State Studies

Although work in other aspects of solid-state is carried out in many locations on the Lehigh campus, the Sherman Fairchild Laboratory provides the focal point for studies of electronic materials and devices. Opened in the fall of 1976, the building provides offices and laboratories for an interdisciplinary staff consisting of faculty from the departments of physics, chemistry, metallurgy/materials engineering, and electrical and computer engineering.

Research activities. A central theme involving the nature and role of defects in insulators and semiconductors runs through the research program. Areas of study include quantum theoretical predictions of electronic properties, fabrication of materials and devices for the study of material processing; the elucidation of fundamental electronic, optical and transport behavior; design, fabrication and characterization of novel electronic devices. The research has a current emphasis on silicon, silicon oxides and silicon-related technology, but also includes work on compound semiconductors; complex insulators such as niobates and titanates, and high-temperature ceramic superconductors.

Central to the functioning of the research program is the Microelectronics Research Laboratory, which provides processing facilities for the fabrication of CMOS, CCD, MNOS, bipolar devices and integrated circuits. Available technology includes low-pressure chemical vapor deposition (LPCVD), RF metallization, plasma chemistry, photolithography, ion implantation, high pressure oxidation, and standard oxidation and diffusion. Design of circuits and devices is aided by an Applicon Color Graphics VLSI system, and a HP-IB system permits automatic data acquisition and analysis of device characteristics.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce electrons for the generation of point defects or positive ions for the analysis of samples—Rutherford Back scattering and proton-induced X-ray emission (PIXE). Individual laboratories provide instrumentation for studies of ceramic materials fabrication, transport properties, optical excitation and luminescence, electron tunneling, electronic conduction and trapping, electron paramagnetic resonance (EPR) and optical detection of magnetic resonance (ODMR), deep level transient spectroscopy (DLTS).

Current research programs include (1) fundamental radiation damage processes in silicon, an experimental and theoretical program aimed at unraveling the fundamental properties of simple lattice point defects in silicon; (2) a study of the electronic and vibronic structure of intrinsic lattice defects in compound semiconductors, an experimental study of the fundamental properties of simple

crystalline point defects in the compound (II-VI, III-V) covalent semiconductors; (3) point defects in insulating solids, experimental studies and theoretical calculations on electron/hole transport, trapping and defective properties; (4) tunneling in MIS memories, an exploration of the dominate physical process in nonvolatile semiconductor memories, namely tunneling of carriers into and through an insulator; (5) VLSI microelectronics, a study of the characterization of small-geometry solid-state devices for VLSI, with emphasis on CMOS transistors; (6) semiconductor charge transport devices, a study of novel device and sensor structures that evolve charge transport and storage. The characterization and modeling of MNOS nonvolatile memory structures; (7) microstructure of electronic materials, microstructural studies of electronic devices, passive components and processing materials to elucidate fundamental mechanisms that govern device performance, to improve device performance and explore novel methods of fabrication.

Educational opportunities. Graduate students in the field of solid-state science and engineering usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, metallurgy and materials engineering, electrical engineering, etc., with specific course requirements and research participation coordinated through the appropriate department chairperson. Students are financially supported by graduate fellowships and undergraduate scholarships provided by the Sherman Fairchild Foundation and/or by university sources. In addition, teaching assistantships are available through the departments and a number of research assistant positions are supported by research grants and contract awards obtained by the laboratory staff. All of these arrangements typically permit graduate students in the solid-state studies to undertake three courses per semester in addition to their teaching or research activities.

For more information, write to Ralph J. Jaccodine, director, Sherman Fairchild Center for Solid-State Studies, Sherman Fairchild Laboratory, Lehigh University, 161 Memorial Dr., E., Bethlehem, Pa. 18015.

Small Business Development Center

(see Musser Center for Entrepreneurship)

The SMART Center

The SMART (Science Model Area Resource Team) Center was established in 1992 to contribute to national efforts to achieve scientific literacy for all Americans. Achievement of this goal requires innovative reforms in the areas of science, mathematics and technology education. Instruments to evaluate, or assess, these reforms also will be needed. Desired outcomes include improving students' attitudes toward pursuing careers in science and increasing the number of women and minorities—populations historically underrepresented in science—entering these fields.

The center serves as an umbrella for a wide variety of training, research and development, and assessment programs for both teachers and students of science, engineering and mathematics. Several disciplines are involved in the activities of the center including: leadership, instruction, and technology; chemical engineering; and school psychology, counseling psychology and special education.

The mission of the Center is to (a) inspire and invigorate students and teachers of science, engineering and mathematics through unique, extracurricular hands-on science opportunities; (b) attract diverse and currently underrepresented populations to pursue careers in science, (c) disseminate innovative curricular materials and (d) encourage research in the science education community.

The center serves as a resource in the promotion of science education activities throughout the region. Elementary and secondary teachers in the region are encouraged to pursue enrichment opportunities offered by the center and leading professional organizations through the dissemination of a quarterly newsletter.

Training/Educational opportunities. The center sponsors workshops and enrichment programs to meet the educational needs of elementary and secondary teachers and students. In addition to presenting the JASON Project annually to over 20,000 Lehigh Valley residents and students, the center is the server site for PSInet, a telecommunications network of local, national and international educators. Periodically the center sponsors teacher workshops and extracurricular science opportunities for students (i.e., SMART Technology and Science, Project METAS). Students enrolled in the College of Education may assist in the development of center workshops.

Research and Development activities. The first of several planned projects is the development of bilingual science modules designed to provide hands-on science activities in the basic education classroom.

Assessment activities. Evaluating the impact of reform efforts is a major focus of the center's activities. A national assessment of the JASON Project and its influence on student attitudes toward science and related careers was conducted during the 1992-93 academic year.

For more information, write to Judith A. Bazler, director, SMART Center, Coppee Hall 309, Lehigh University, 33 Coppee Drive, Bethlehem, Pa. 18015-3165.

Technology Studies Resource Center

The Technology Studies Resource Center, based in the College of Arts and Science, creates and disseminates materials and programming that will lead a wide range of people to an understanding of the mutual interaction of technology, and social institutions and values. Through the center, academics from all disciplines can collaborate on research and develop educational opportunities in technology studies with academic colleagues and with non-academic sponsors.

The Technology Studies Resource Center's activities embrace the needs of academics, pre-college and college students, and industrial, political, and public audiences, who seek information about technology as a force in contemporary society. Four principal areas for activities are the development and dissemination of resource materials, professional development programming, educational programming, and stimulation and coordination of technology studies and research projects. Specific activities include: collecting and distributing college-level course syllabi in technology studies; publishing bibliographies in specific areas of technology studies; sponsoring a regional colloquium in technology studies and publishing its best presentations in a working papers format; editing the continuing book series RESEARCH IN TECHNOLOGY STUDIES; publishing the SCIENCE, TECHNOLOGY, AND SOCIETY CURRICULUM DEVELOPMENT NEWSLETTER; maintenance of a data base of personnel, curricula, and materials resources in technology studies; sponsoring conferences, workshops, seminars and institutes in technology studies; and integrating technology studies material with existing high school curricula and developing better courses in science and mathematics in cooperation with regional administrators and faculty.

For more information write to Stephen H. Cutcliffe, Maginnes Hall, Lehigh University, 9 W. Packer Avenue, Bethlehem, Pa. 18015.

Zettlemoyer Center for Surface Studies

The Zettlemoyer Center for Surface Studies was established on February 1, 1966. The center has been successful in fostering interdisciplinary research in a broad range of surface-related phenomena including lipid membranes, catalysis, corrosion, environment-enhanced cracking in alloys, coatings, dispersions, printing inks, and colloids. Faculty members from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, and materials science and engineering are associated with the center. The center develops and

maintains research facilities, including laboratory and office space, and major experimental equipment used in surface-related research. The center facilitates interchanges of ideas and interactions between faculty and students from different disciplines, thereby nurturing research at the forefront of science and broadening the educational opportunities for graduate as well as undergraduate students.

Financial support for the center comes largely from research projects with industries and governmental agencies.

The center is well equipped with specialty instrumentation needed for advance research in its field. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Moessbauer spectroscopy, Auger spectroscopy, laser Raman spectroscopy, infrared spectroscopy, X-ray photoelectron spectroscopy, electron spectroscopy for chemical analysis, high resolution electron energy loss spectroscopy, low energy electron diffraction, ultraviolet photoelectron spectroscopy, nanosecond fluorescence spectroscopy, ellipsometry, computerized spectrophotometry, positron annihilation spectroscopy, electrochemical impedance spectroscopy, microelectrophoresis, and continuous electrophoresis.

Other specialty equipment includes microbalances, testing machines for studies of environment-affected crack growth, gas adsorption and heat of immersion apparatus, wetting balances, apparatus for determining rheological properties, and apparatus for the preparation of reproducible dispersions and films.

Research activities. The center's research program includes a broad range of topics vital to modern science and technology.

Some of the active topics are: solid-state chemistry of catalysts; catalytic oxidation of methane; mechanisms of catalytic reactions and development of new catalysts; formation of monolayer oxides on oxides of a different metal, the interaction between these oxides and relationship with catalytic activity; surface magnetic properties; wetting of multiphase systems; characterization of surfaces; microelectrophoresis and continuous electrophoresis; Moessbauer spectroscopy of surfaces; erosion and wear, chemical composition of surfaces; passivity and corrosion inhibition; chemistry of fracture surfaces, hydrogen embrittlement; environmentally affected crack growth; high-temperature corrosion; coatings for protecting microelectronic circuits; adhesion of coatings; corrosion under coatings; chemical state of ions in polymers; charge transport through organic coatings; effect of metallic cations on corrosion processes; water-based coating; electrical properties of coatings; polymer surfaces; research related lithographic, flexographic and gravure printing; rheology in non-Newtonian fluids; and adhesion and flow of fluids in porous substrates.

Educational opportunities. The center is a facility in which graduate students undertake thesis and dissertation research leading to the M.S. or Ph.D. degrees in the departments of chemistry, chemical engineering, physics, mathematics, biology, materials science and engineering, and mechanical engineering and mechanics.

Potential and current graduate students whose interests are consistent with the center's objectives are welcome to avail themselves of the experimental facilities. Research assistantships are available. Research topics are selected by mutual agreement, and interested students are encouraged to explore research opportunities in the center.

The center's research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in Sinclair Laboratory accommodates the special seminars and short courses that are held periodically. Recent course topics include corrosion, printing ink technology, adhesion, and molecular design/characterization of catalytic oxide materials.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For more information, write to the director, Gary W. Simmons, Sinclair Laboratory, Lehigh University, 7 Asa Drive, Bethlehem, Pa. 18015.

Organizational Headquarters for Applied Technology

Ben Franklin Technology Center

The Northeast Tier Ben Franklin Technology Center (NET/BFTC), based in the Ben Franklin Building on the Murray H. Goodman Campus, was established in 1983 as part of the commonwealth's Ben Franklin Partnership. A program of the Pennsylvania Economic Development Partnership, Ben Franklin supports and promotes technological innovation in the commonwealth.

The Partnership aims to combine the resources and expertise found throughout the state's educational system with business's technology-advancement efforts to create products and improve manufacturing processes and productivity. Through these efforts, the Ben Franklin program serves to make the state's economy more innovative and competitive, thus creating and retaining high quality job opportunities in Pennsylvania. The technology center at Lehigh is one of four centers in the state working with business, education and government toward these goals; the other centers are based at the University City Science Center, Philadelphia; Pennsylvania State University, University Park; and Carnegie-Mellon University/University of Pittsburgh.

The NET/BFTC works with a consortium that includes more than 1000 companies, 84 schools and 107 community, government and other organizations in northeastern Pennsylvania. Its goals include helping new technology-oriented businesses to form and grow, helping existing manufacturers to improve productivity through new technologies and practices, and serving as a catalyst for related economic development activities in the region. Technical and business assistance services are provided on a year-round basis. The center also operates a business incubator center right on the Lehigh campus, and it seeds the development of creative new education and training programs that meet the needs of industry.

For the 1992-93 funding year, the NET/BFTC was awarded \$5.1 million from the state Department of Commerce and \$14.2 million in matching funds from private-sector businesses, educational institutions and other sources. The NET/BFTC has over 25 projects with Lehigh, involving approximately 150 faculty members, research scientists, project engineers, students, technicians, and administrative staff.

For more information, contact Mark S. Lang, executive director, Ben Franklin Center, 125 Goodman Drive, Lehigh University, Bethlehem, Pa. 18015-3715; (215) 758-5200.

Council on Tall Buildings and Urban Habitat

The Council on Tall Buildings and Urban Habitat, an international activity sponsored by engineering, architectural, and planning professionals, was established in 1969 to study and report on all aspects of the planning, design, construction, and operation of tall buildings.

The Council's nine professional society sponsors are: International Association for Bridge and Structural Engineering, American Society of Civil Engineers, American Institute of Architects, American Planning Association, International Union of Architects, American Society of Interior Designers, Japan Structural Consultants Association, Urban Land Institute, and International Federation of Interior Designers. In 1974 the Council was admitted as a consulting nongovernmental organization to United Nations Educational, Scientific and Cultural Organization under Category C. In 1979 it was upgraded in its interactions with UNESCO to Category B.

The Council is concerned with the impact of tall buildings

on the urban environment and in the role they play in urban life. This involves a systematic study of the problem of providing adequate space for life and work, considering not only technological factors, but social and cultural aspects as well. Important activities include the identification and stimulation of needed research and implementation of findings into codes, specifications, and standards.

The seven groups that carry out the major activities of the Council are Planning and Environmental Criteria for Tall Buildings (PC); Development and Management (DM); Tall Building Systems and Concepts (SC); Building Service Systems (BSS); Tall Building Criteria and Loading (CL); Structural Design of Tall Steel Buildings (SB); and Structural Design of Tall Concrete and Masonry Buildings (CB).

A major focus of the Council is a comprehensive multi-volume monograph on the planning and design of tall buildings entitled *Tall Buildings and the Urban Environment*. They cover environmental aspects, transportation and other planning aspects; service systems, structural systems; the various loading systems; structural safety, foundations, and structural design methods and limit states—the latter covering both steel and concrete buildings.

The Council is not an advocate for tall buildings, *per se*, but in those situations in which such buildings are viable, it seeks to encourage the use of the latest knowledge in their implementation.

The headquarters of the Council is at Lehigh University. Nearly 1,200 specialists, primarily engineers, architects, planners, and sociologists from seventy countries, are involved in the work of its committees. A number of these committees provide advisory guidance for relevant Lehigh research projects.

For more detailed information, contact Director Lynn S. Beedle, Lehigh University, 13 E. Packer Avenue, Bethlehem, Pa. 18015; Phone: (215) 758-3515, FAX: (215) 758-4522.

Manufacturers Resource Center

The Manufacturers Resource Center (MRC) is one of eight Industrial Resource Centers networked across Pennsylvania with the sole mission of assisting small and medium-size manufacturers to ensure they remain competitive in the current global marketplace.

The MRC offers manufacturers valuable assistance by helping companies to use off-the-shelf technology and proven techniques to compete in today's economy. That includes all aspects of business from quality to information systems and production constraints. One-on-one projects are the focal activity of the Center. Each staff manufacturing engineer provides customized analysis for each client, personally defining their particular constraints, and working with them through projects to arrive at solutions. Beyond the information and expertise, the staff engineers act as project managers to the client as they work with a network of private and academic consultants.

Typical services fall into the following categories: manufacturing strategies and plant operations; technology improvement; production planning and inventory control; factory automation; quality management; information systems; equipment justification; plant layout; fixed asset and cost management; business planning and systems layout; work force development; market expansion; labor/management relations; and quality, productivity, marketing and information systems reviews.

Resources available through MRC are experienced staff and industry professionals, private and academic consultants, customized training programs, library of manufacturing materials and access to databases. Additionally, technical demonstration sites have been established where manufacturers are able to observe, learn, and try new technologies. These sites include CIMLab, Lehigh University, Northampton Community College, and the IRC's Shop With a Future.

The MRC serves seven counties in Northeast Pennsylvania and is a member corporation of Lehigh University. A sister organization to the Ben Franklin Technology Center, the Center is funded by the Pennsylvania Department of Commerce and has the support of private industry.

Additional services available through MRC include industry initiatives, regional seminars and training, quality initiatives and ISO 9000 certification seminars. For further information or assistance, please contact Edith Ritter, Executive Director, at (215) 758-5599.

Structural Stability

Research Council

The Structural Stability Research Council (formerly Column Research Council) was founded in 1944 by the Engineering Foundation to review and resolve the conflicting opinions and practices that existed at that time with respect to solutions to stability problems, and to facilitate and promote economical and safe design. The Council has been headquartered at Fritz Engineering Laboratory since 1966.

At the core of the Council's activities are 16 task groups and 8 task reporters. At its Annual Technical Session, a forum is provided whereby the latest research results pertaining to these groups are presented. This represents a primary source of the highlights of the latest solutions to structural problems before they are eventually published in technical journals.

The Council offers guidance to specification writers and practicing engineers by developing both simplified and

refined calculation procedures for the solution of stability problems, and assessing the limitations of these procedures. The Council's major publication is the *Guide to Stability Design Criteria for Metal Structures*. Now in its fourth edition, this book is the most comprehensive treatment available anywhere in the world on stability problems associated with metal structures.

The international membership of the Council is made up of representatives from governmental and private organizations concerned with specifications and design procedures for metal structures, representatives of consulting firms engaged in engineering practice, members-at-large selected from universities and design offices, and corresponding members from various countries who are in touch with stability research in their region.

A number of Fritz Engineering Laboratory research projects have received the guidance of the Council's advisory committees. Many former Lehigh University graduate students and research workers are now active members of the Council. Many of them are expected to participate in the SSRC's 50th Anniversary celebration to be held on Lehigh campus in June 1994.

For more detailed information, contact SSRC Headquarters, Fritz Engineering Laboratory, 13 E. Packer Avenue, Lehigh University, Bethlehem, PA 18015.

V.



Courses Programs and Curricula

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of preregistration.

All academic departments are listed in alphabetical order.

Credit Hours

The number in parentheses following each course title indicates the credit value of the course in terms of semester hours ("credit hours"). Three hours of drawing, of work in the laboratory, or of practice in the field are regarded as the equivalent of a recitation or lecture of one hour's duration.

Course Numbering

The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Courses primarily for freshmen or sophomores. Not available for graduate credit.

100-199. Intermediate-level undergraduate courses. Not open to freshmen except on petition. Not available for graduate credit.

200-299. Advanced undergraduate courses. Courses in the College of Business and Economics and specific departments as noted in the listings are open to freshmen and sophomores only on petition. Not available for graduate credit in the major field.

300-399. Advanced undergraduate courses. Same as 200-299, but available for graduate credit in major field.

400-499. Graduate-level courses, open to undergraduates only by petition.

Provisional Courses

Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses can become a permanent part of the university curriculum. These courses are numbered, as is appropriate, . . . 95-98 . . . 195-198, . . . 295-298, . . . 395-398, for a maximum of two semesters.

Students may take 95-98 series courses pass/fail under the standard procedures for pass/fail.

Apprentice Teaching and Cooperative Undergraduate Education

For details of these programs, see descriptions under "Apprentice Teaching" and "Cooperative Undergraduate Education," in section III.

Prerequisites

Academic preparation required for admission to courses is indicated under "prerequisites" included at the end of each course description. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Academic status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status (e.g., sophomore standing) or the academic preparation set forth as prerequisites must, in order to be admitted to a course, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the course instructor, the teaching department chair and either the chair of the student's major department or the associate dean. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

In a few cases, corequisites are indicated. In such instances the corequisite course is taken in the same semester.

Information Limits

The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will have a significantly broader scope than the topics listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is suggested that the student confer with the adviser.

Accounting

Professors. James A. Largay, III, Ph.D. (Cornell), *C.P.A.*, *Arthur Andersen & Co. Alumni Professor of Accounting*; Frank S. Luh, Ph.D. (Ohio State); Kenneth P. Sinclair, Ph.D. (Massachusetts), *chairman*.

Associate professors. D. Raymond Bainbridge, Ph.D. (Lehigh), *C.P.A.*; Michael L. Davis, Ph.D. (Massachusetts), *C.P.A.*; James A. Hall, Ph.D. (Oklahoma State), *Deloitte & Touche Information Systems Fellow*; John W. Paul, Ph.D. (Lehigh), *C.P.A.*; James E. Rebele, Ph.D. (Indiana).

Assistant professors. Karen M. Collins, Ph.D. (VPI), *C.P.A.*; Marilyn M. Greenstein, Ph.D. (Temple); Parveen P. Gupta, Ph.D. (Penn State); Robyn Lawrence, Ph.D. (Houston); Manash R. Ray, Ph.D. (Penn State).

Adjuncts. Daniel A. Bayak, M.B.A. (Scranton), *C.P.A.*, *C.M.A.*; M. Taylor Ernst, M.B.A. (Lehigh), *C.P.A.*; Robert H. Mills, Ph.D. (Wisconsin), *C.P.A.*

The Department of Accounting offers a wide variety of courses in accounting which: support the College of Business and Economics core requirements; provide an undergraduate major in accounting; are elective courses for other College of Business and Economics undergraduate

majors; and form a key component of the Master of Business Administration program. The upper-level undergraduate courses have a professional accounting orientation which continues to sustain a large enrollment in the accounting major. Within the major, there is the opportunity to explore the various career opportunities within the broad field of accounting: financial, managerial, taxation, auditing, and information systems.

Objectives of the Accounting Program

The primary goals of Lehigh's undergraduate program leading to the Bachelor of Science degree in Business and Economics with a major in accounting are to:

Cultivate an inquiring mind and kindle the student's interest in lifelong learning

Subject the student to a rigorous academic program in the liberal arts in addition to business and economics

Provide the student with a theoretical framework as well as problem-solving skills in each of the following areas in accounting: financial, managerial, information systems, auditing, and taxation

Encourage the development of interpersonal skills including oral and written communication skills

Promote self-development through participation in extracurricular and social activities.

To the extent the above objectives are achieved, the graduate is prepared for the following: an entry level position in industry, not-for-profit organizations, public accounting; self-employment; and graduate studies. This academic program prepares interested students for relevant professional accounting examinations.

The Accounting Major

The undergraduate program in accounting is accredited (Type A) by the American Assembly of Collegiate Schools of Business. This achievement places the program within a small group of schools nationally which have satisfied a rigorous examination of the program, faculty, and students beyond the accreditation standards applied to the College of Business and Economics undergraduate and graduate programs.

The program is offered in the College of Business and Economics. Required: 18 credit hours beyond core requirements.

Acct 307	Fundamentals of Federal Income Taxation (3)
Acct 311	Accounting Information Systems (3)
Acct 315	Financial Accounting I (3)
Acct 316	Financial Accounting II (3)
Acct 320	Fundamentals of Auditing (3)
Acct 324	Cost Accounting (3)

Undergraduate Courses in Accounting

151. Introduction to Financial Accounting (3)

The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, information processing, and financial statements. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

152. Introduction to Managerial Accounting (3)

An introduction to internal accounting information for all levels of management. Topics include cost flow in a manufacturing operation; planning, evaluating and controlling through budgeting and standard costing; and decision-making using cost-volume-profit analysis, direct costing, and relevant costs. Prerequisite: Acct 151.

108. Fundamentals of Accounting (3)

A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed for those students planning to take only one accounting course. Other students should take the Acct 151-152 sequence.

111. Management Information Systems in Business (3)

An introduction to information systems with an emphasis on business applications. Students develop a working knowledge of a computer language sufficient to solve business problems. Basic knowledge of hardware, software, computer systems, and the systems development process. File organizations, the data base concept and distributed data processing systems are covered. Prerequisite: Mgt 1.

211. Management Information Systems

This course examines the role of information and information systems in business organizations. Computer based information systems play a fundamental role in data processing, management decision support, manufacturing/production control, and internal and external reporting. This course integrates system concepts, organization theory, decision making, and technology critical to the understanding of routine business applications and the strategic use of information systems. Prerequisites: Acct 152, Mgt 1 and Mgt 270. Students will not receive credit for both Acct 111 and Acct 211.

Advanced Undergraduates and Graduate Students

307. Fundamentals of Federal Income Taxation (3)

An introductory study of the principles and concepts of federal income taxation of individuals, corporations, partnerships, and fiduciaries; and federal gift and estate taxes. Determination of tax liabilities and opportunities for planning are emphasized. Problem-solving using the source materials of tax law and tax research are important components of the course. Prerequisite: Acct 151.

309. Advanced Federal Income Taxation (3)

An advanced study of the taxation of business organizations, estates, trust, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Acct 307.

311. Accounting Information Systems (3)

An introduction to the concepts underlying information systems as they relate to organizational structure, managerial decision making and accounting. The course acquaints students with the reports and documents generated by information systems, as well as procedures and controls employed in a variety of business applications. Students apply these concepts, techniques and procedures to the planning, analysis and design of manual and computer based information systems. Prerequisites: Acct 152, Mgt 1, and Mgt 270. Students will not receive credit for both Acct 211 and Acct 311.

315. Financial Accounting I (3)

Intensive study of the basic concepts and principles of financial accounting, emphasizing the problems of fair presentation of an entity's financial position and operating results. Consideration of the conceptual framework of accounting, review of the accounting process, and measurement and valuation of current assets, current liabilities, plant assets, intangibles, investments, and long-term debt. Problem-solving skills and critical analysis are stressed. Prerequisite: Acct 152.

316. Financial Accounting II (3)

The sequel to Accounting 315, this course continues with intensive study of such topics as stockholders' equity, valuation and disclosure of leases and pensions, income tax allocation, changing prices, revenue issues, earnings per share, and complexities related to the statement of changes in financial position. Analysis and interpretation of financial

statements and problem-solving skills are integral parts of the course. Prerequisite: Acct 315.

317. Advanced Financial Accounting (3)

A study of specialized topics in financial accounting, including partnership accounting, business combinations and consolidated financial statements, segment and interim reporting, foreign currency transactions and translation, and accounting and reporting for governmental and other nonprofit organizations. Involves considerable problem-solving and critical evaluation of controversial theoretical issues. Prerequisite: Acct 315 or 316.

320. Fundamentals of Auditing (3)

An introduction to auditing theory, objectives, and practices related largely to the responsibilities of independent professional accountants. The auditing environment, generally accepted auditing standards, internal control theory, and reporting alternatives are considered. Exposure to operational auditing is provided. Prerequisites: Acct 311 and 315.

324. Cost Accounting (3)

An in-depth study of cost concepts appropriate for product costing in a manufacturing operation, planning and controlling routine operations, and nonroutine decision-making. Topics include job order and process costing, joint and by-products, cost allocation, budgeting, standard costing, direct costing, cost-volume-profit analysis, and relevant costs for decisions. Prerequisite: Acct 152.

371. Directed Readings (1-3)

Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the department chairperson.

372. Special Topics (1-3)

Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the department chairperson.

390. Internship (1-6)

Designed to give advanced students of accounting, who have maintained a satisfactory standard of scholarship and who show promise in the field of accounting, an opportunity to acquire field experience and training with selected industrial or public accounting firms or governmental agencies as a complement to the academic learning process. Outside readings are assigned. Written reports are submitted by students and a performance evaluation is made by the employer. The amount of credit is influenced by the length of the training period. Prerequisite: junior standing and approval of the faculty committee on internship.

Graduate Courses in Accounting

Undergraduates may wish to plan a program that includes the M.B.A. degree as part of the professional accounting preparation. For information about C.P.A. requirements in different states, the C.M.A. certificate, or for the selection of accounting electives, consult the department chairperson.

403. Financial Flows and Accounting Measurements (3)

Corporate financial reporting: identification, accumulation and communication of financial information to management and other users. Generally accepted accounting principles, uses and limitations of accounting information, asset valuation, income determination, funds flows, and analysis and interpretation of financial statements.

413. Managerial Accounting and Decision-Making (3)

Cost accounting techniques for management planning and control. Responsibility accounting, budgeting, cost behavior, cost estimating, and allocation, product costing,

relevant costs, cost variance analysis, information requirements. Prerequisite: Acct 403 or equivalent.

421. Information Systems for Managers (3)

Information processing, computer, and data structure concepts in producing information. Communications between user management and data processing management in the systems development process. Control of systems development activities, data based systems, and distributive processing systems. Projects and case studies. Prerequisites: Mgt 413 (or concurrently) and Acct 403.

431. Accounting Theory and Thought (3)

Critical and historical examination of modern accounting concepts. Measurement, communication, and interpretation of enterprise income, capital, and related economic data. Prerequisite: 15 credit hours of accounting.

433. (IE 408) Management Information Systems (3)

Integrated and total systems concepts for organizational data bases and information systems as applied to planning, development and implementation of computer-based management information systems. Emphasis placed on the interaction of information systems with management planning and control. Prerequisite: an advanced course in information systems and a knowledge of programming.

435. Advanced Management Accounting (3)

Issues in management accounting including activity based costing, strategic cost management, theory of constraints, advanced manufacturing technologies, cost of quality, and life cycle costing. Readings and cases. Prerequisite: Acct 413 or a course in cost accounting.

439. Contemporary Issues in Financial Reporting (3)

Corporate financial reports from the perspective of the user-analyst: disclosure, price level accounting, foreign currency, business combinations, leases, and analysis of financial statements. Case studies. Prerequisite: Acct 413.

471. Directed Readings (1-3)

An extended study of an approved topic in the fields of accounting. May be repeated.

472. Special Topics (1-3)

Special problems and issues in accounting and law for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the department chairman. May be repeated.

African American Studies

Professors. William R. Scott, Ph.D. (Princeton), Professor of History, *program director*; Elizabeth N. Fifer, Ph.D. (Michigan), *professor of English*; Barbara B. Frankel, Ph.D. (Princeton), *professor of sociology and anthropology*; Richard K. Matthews, Ph.D. (Toronto), *professor of government*; Edward P. Morgan, Ph.D. (Brandeis), *professor of government*.

Assistant professors. Berrisford W. Boothe, M.F.A. (Maryland Institute College of Art), *assistant professor of art and architecture*; Christine Daniels, Ph.D. (Johns Hopkins University), *assistant professor of history*; Frankie Hutton, Ph.D. (Rutgers), *assistant professor of journalism*; Melvin Thomas, Ph.D. (Virginia Polytechnic), *assistant professor of sociology and anthropology*; E. Tina Richardson, Ph.D. (Maryland), *assistant professor of counseling psychology*.

Adjunct professors. Karen R. Keim, Ph.D. (Indiana), Center for International Studies.

The purpose of the African American Studies Program is to engender in Lehigh students an intellectual appreciation of the life and culture of people of African descent in the Americas, especially the United States—thereby enriching the Lehigh curriculum and increasing the relevance of a

Lehigh education to a culturally diverse society and world. In the best tradition of a liberal arts education, African American Studies expands all Lehigh students' critical understanding of their own heritage in interaction with other cultures.

The minor in African American Studies is an interdepartmental and comparative program of study for undergraduates who wish to integrate the insights and methods of several disciplines to understand the history, culture, social, and political experience of African Americans. The African American Studies curriculum encompasses two interrelated lines of inquiry: (1) the diverse influences in Africa and the diaspora that have shaped African American culture, and (2) the variety of ways that the African American experience has shaped and been shaped by American culture.

The Minor

The minor in African American Studies consists of a minimum of 15 credit hours taken in the courses (core and collateral) listed below. At least nine (9) credit hours must be selected from the Core Course grouping (excluding independent and special topics), no more than six hours of which may be offered by the same department. In addition to the listed courses, students are encouraged to pursue independent study opportunities with faculty in the African American Studies Program.

Core Courses:

Core courses concentrate on subject material directly relevant to the African American experience. They are devoted explicitly to the study of the African American experience or heritage.

AAS 3 Introduction to African American Studies (3)

An interdisciplinary study of key aspects of the past, the culture and political experience of African Americans. The history of Africans in America, cultural continuities among African peoples worldwide, and social forces that have shaped modern African American life. Scott

AAS/Hist 5 African Civilization (3)

Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade; colonialism, resistance to European rule; independence movements; neocolonialism. Scott

AAS/Engl 38 Introduction to African Literature (3)

Sub-Saharan African literary themes and styles; historical and social contexts African folktales; oral poetry; colonial protest literature; postcolonial writing; films on contemporary Africa. Keim, Scott

AAS/Soc 103 Race Relations (3)

Racism, discrimination and prejudice, racial and ethnic conflict, and racial oppression in American society; the Civil Rights Movement. Problems faced by Blacks, Hispanics, Native Americans, and Asians in contemporary United States.

AAS/Hist 129 Black Political Thought in America (3)

Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. Scott

AAS/Hist 130 African American History to 1865 (3)

Blacks in North America and the West Indies from first importation of Africans until end of the Civil War; West African origins, slave trade; variant slave systems; black culture; free blacks, manumission, proslavery ideology and blacks during the Civil War. Daniels

AAS/Hist 131 African American History Since 1865 (3)

Failure of Reconstruction; sharecropping; Jim Crowism; segregation; lynching; urban migration; Harlem Renaissance; New Deal; Civil Rights Movement; affirmative action. Hutton

AAS/Hist 171 History of Southern Africa (3)

Africa south of the Zambezi, especially after the arrival of the Europeans. Conflicts in the Cape between Africans, the Boers and British; exploitation of minerals; apartheid, American policy; socialism in Angola and Mozambique. Scott

AAS/Hist 271 The United States and Africa (3)

Reciprocal relationships between North America and the African continent from the slave trade in seventeenth century to twentieth century Afrocentric movement. Impact of Americans on shaping of modern Africa, Pan-African relations, influence of African Americans on U.S. policies toward Africa. Scott

AAS 371, 372 Independent Study (1-3)

Independent study in advanced areas of African American Studies. Independent research with an individual faculty member in the African American Studies program. Consent of director.

AAS/Soc 379 Race and Class in America

Race and class in America and how these two organizing principles affect the lives of African Americans and other racial minorities. "Race versus class debate, with special attention to differences between the Black underclass and Black middle class. Thomas

AAS 381 Special Topics

382 Seminar on a topic in African American Studies

Collateral Courses

Anthro 12	Human Evolution and Prehistory
Hist 334	American Urban History, 1880 To Present
Govt 330	The Politics Of The 1960s
Govt 352	Civil Rights

American Studies

American Studies Committee. William G. Shade, Ph.D. (Wayne State), *professor of history and director of American Studies*; David Curtis Amidon, Jr., M.A. (Penn State), *lecturer in urban studies*; Peter G. Beidler, Ph.D. (Lehigh), *Lucy G. Moses Distinguished Professor of English*; Joseph A. Dowling, Ph.D. (N.Y.U.), *distinguished professor of history*; Michael L. Raposa, Ph.D. (Pennsylvania), *associate professor of religion studies*; James R. Frakes, Ph.D. (Pennsylvania), *Edmund W. Fairchild Professor of American Studies*; Edward J. Gallagher, Ph.D. (Notre Dame), *professor of English*; James R. McIntosh, Ph.D. (Syracuse), *professor of sociology*; Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany), *professor of government*.

American Studies is an interdepartmental major emphasizing the idea that the institutions and values of a society comprise a whole, not merely the sum of its parts. By concentrating on the unique expressions of individuals contained in both the arts and popular culture and by studying the historical movements and contemporary institutions within which these expressions develop, American Studies reveals relationships that may not be clearly seen within the framework of a single discipline.

The broad interdisciplinary nature of American Studies equips the student with a well-rounded general education and a wide range of career opportunities. The student may choose to emphasize American history or literature to provide an excellent preparation for graduate school in these areas as well as in American Studies. In addition the major can be combined with other majors, such as journalism, or minors, such as Law and Legal Institutions, to furnish a sound underpinning for careers in those areas. With suitable collateral courses, the major also can prepare students for advanced work in museum administration, library science, social work and for teaching in both secondary schools and community colleges.

The major consists of fifteen credit hours of preliminary courses dealing with American literature, history, and popular culture. All students are also required to take two American Studies courses, one at the intermediate level introducing the general approach of the major and a senior seminar on contemporary American civilization. In connection with the director of American Studies, who serves as the adviser for the major, each student chooses a program of fifteen semester hours of upper-level courses drawn from four different groups. The major requirements total 36 credit hours.

required preliminary courses (15 credit hours)

Hist 9	Survey of American History I (3)
Hist 10	Survey of American History II (3)
Engl 123	American Literature I (3)
Engl 124	American Literature II (3)

Choose three hours in the area of American Popular Culture from the following:

Engl 63	Narrative Film (3)
Engl 89	Science Fiction (3)
Engl 189	Popular Literature (1-3)
Hist 7	Machine in America (3)
Rel 53	Religion and the American Experience (3)

required American Studies courses (6)

Intermediate level: Arts 111, The American Character (3)
Upper-level seminar: Arts 311, Themes in Contemporary American Civilization (3)

required upper-level courses (15)

Choose at least six hours each from two groups.

Literature

Engl 376	Early American Literature (3)
Engl 377	American Romanticism (3)
Engl 378	American Realism (3)
Engl 379	Twentieth-Century American Literature (3)
Engl 380	Contemporary American Literature (3)
Engl 382	Themes in American Literature (3)

History

Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)

Government and Society

Govt 317	The American Presidency (3)
Govt 330	Politics of the 1960s
Govt 351	Constitutional Law (3)
US 321	White Protestant Americans (3)
Soc 141	Social Deviance (3)
Soc 153	Alcohol, Science and Society
Soc 364	Lifestyle and the Family (3)

Choose three hours from the following

Minorities in America

US 328	The American Jewish Community (3)
Engl 311	Literature of Women (3)
Engl 316	The Indian in American Literature (3)
Hist 130	The Black Experience to 1865 (3)
Hist 131	The Black Experience in America (3)
Hist 124	Women in America (3)
Anth 182	North American Indians (3)
Soc 103	Race, Ethnicity and Minorities

The courses listed here are recommended, but comparable

courses in each of these areas may be substituted with written permission of the director of American Studies.

Admission to honors in American Studies is by invitation of the committee in the student's junior year. The student must attain an average of 3.2 in major courses in addition to the university honors requirements.

Anthropology

See listings under Sociology and Anthropology.

Applied Mathematics and Statistics

Professors. Edward F. Assmus, Jr., Ph.D. (Harvard); Dominic G. B. Edelen, Ph.D. (Johns Hopkins); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Guldén, M.A. (Princeton); Gregory T. McAllister, Ph.D. (Berkeley), *head*; George E. McCluskey, Ph.D. (Pennsylvania); Eric P. Salathe, Ph.D. (Brown); Murray Schechter, Ph.D. (N.Y.U.); Gilbert A. Stengle, Ph.D. (Wisconsin).

Associate professors. Wei-Min Huang, Ph.D. (Rochester); Ramamirtham Venkataraman, Ph.D. (Brown); Penny Smith, Ph.D. (Poly. Inst. Brooklyn); Joseph E. Yukich, Ph.D. (M.I.T.).

The *Division of Applied Mathematics and Statistics* was established within the Department of Mathematics to promote and administer undergraduate and graduate education in applied mathematics and statistics, and to foster interdisciplinary research in the mathematical sciences at Lehigh. Courses and programs offered by the Division may be found under the departmental listing.

For a description of the graduate programs in Applied Mathematics, see the discussion under Interdisciplinary Graduate Programs on page 50 in Section IV.

Art and Architecture

Professors. Tom F. Peters, M.Arch (ETH Zurich (dipl.Arch.ETH) and Dr.sc. (techn.) ETH Zurich, *director, Institute for the Study of High-Rise Habitat*; Richard J. Redd, M.F.A. (Iowa); Ricardo Viera, M.F.A. (R.I.S.D.), *director of Lehigh University Art Galleries*.

Associate professors. Ivan Zaknic, M.Arch. and Urban Planning (Princeton), *chairman*; Lucy Gans, M.F.A. (Pratt).

Assistant professors. Berrisford W. Boothe, M.F.A. (Maryland Institute College of Art); Bruce Thomas, Ph.D. (Univ. of Calif., Berkeley); Anthony Viscardi, M.Arch (Georgia Institute of Technology).

Lecturer. Christine Ussler-Trumbull, M.Arch (Columbia University).

Adjunct professor. George Shortess, Ph.D. (Brown).

Adjunct assistant professor. Ann Priester, Ph.D. (Princeton).

Adjunct lecturers. Steven Anderson; Myron Barnstone; Anthony Corallo; Ben Marcune; Douglas Mason.

The department of art and architecture offers two major programs:

The architecture major is a multidisciplinary major based in the department that draws on the resources of all Lehigh's colleges. Although architectural design is the primary concern of this major (beginning students should take Arch 1 and Art 7) courses in architectural history, social sciences and engineering are recommended.

The architecture major leads to the liberal arts B.A. (bachelor of arts), a four-year degree. This degree is

satisfactory for admission to graduate study in architecture and candidacy for the M.Arch. professional degree or for planning, preservation, or history of architecture.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Penn, Columbia, University of Pennsylvania, Maryland and Washington University, among other schools, or to entry-level employment in the profession.

Double majors with Urban Studies are quite frequent and the Arts/Engineering five-year degree, in which the student earns both B.A. (architecture) and B.S. (civil engineering), is available. For engineering students considering graduate study in architecture or entry-level positions in an architectural-engineering firm an architecture minor is generally appropriate.

A major in art introduces the student to the basic media of art such as drawing, sculpture, printmaking, painting, and photography. For those interested in becoming creative artists, intensive study at Lehigh as well as the other Lehigh Valley colleges is recommended; such a student can expect to take more than the required number of credits for the major.

A major in art can also be combined with psychology for those who seek a career in art therapy. It may also be combined with theater for those interested in costume design or with architecture and theater for those interested in set design. A major in art and minor in education is available for students interested in becoming public school art teachers.

A special track is available within the art major for students interested in art history.

The resources of the Lehigh University art collection are made available to many students taking classes in art. Prints, photographs, and paintings are often brought into the classroom and visits to art exhibitions on campus and elsewhere in the Lehigh Valley are a common part of art instruction.

Through the facilities of the Lehigh University art galleries, it is possible to see first-rate works of art on a regular basis. The annual contemporary art show is a special event. Several major museums are within easy traveling distance and the department runs regular bus trips to New York City. An annual lecture series has brought architects and artists to campus. In recent years Rodolfo Machado, Charles Gwathmey, Klaus Herdeg, Edmund Bacon, Steven Peterson, Tod Williams, Peter Eisenman, Thomas Armstrong, Rev. Howard Finster, Joyce Kozloff, Jonas Dos Santos, Geno Rodriguez, Harold Edgerton, Peter Berg, Jody Pinto have appeared at Lehigh. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics.

In addition to these two major programs, individually structured programs may be planned, such as art with an emphasis on architectural design, art history with an emphasis on museum training, and architecture with an emphasis on planning, urban studies, graphic communication, or government.

Minor programs have been established in architecture, art, studio art, art/architecture history, graphic communication, and museum studies. Course requirements are specified, and a list of courses acceptable for the minors is available in the department.

Art Major

Forty-two credit hours are required.

required preliminary courses (21 credit hours)

Art/Arch 1	Art/Architectural History I (3) or
Art 2	Art History II (3)
Art 7	Basic Design (3)
Art 11	Drawing I (3)
Art 13	Sculpture I (3)
Art 20	Color (3)
Art 111	Drawing II (3)
Art 220	20th-Century Art (3)

plus one of the following:

Art 65	Perception and the Visual Arts (3)
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Art 82	Art and Archaeology of Greece (3)
Art 121	Women in Art (3)
Art 165	Perception and Visual Arts Studio (3)
Arch 210	20th-Century Architecture (3)
Art 218	Romanticism and Realism (2)
Art 221	Impressionist and Post-Impressionist Painting (2)

six required major courses (18 credit hours)

Art studio: six courses, two at the advanced level

Students interested in an art history concentration should substitute two preliminary studio courses with Art 1 and Art 2 or Arch 1. For the six required courses in art studio, courses in art history and museum studies should be substituted in consultation with an adviser. In order to complete an art history concentration students may be required to take courses in other LVAIC institutions.

Architecture Major

Forty-nine credit hours are required.

Design Sequence (22 credit hours)

Arch 43	Architectural Design I (4)
Arch 143	Architectural Design II (6)
Arch 243	Architectural Design III (6)
Arch 343	Architectural Design IV (6)

Art Studio (9 credit hours)

Art 7	Basic Design (3)
Art 11	Drawing I (3)
plus one other studio (3)	

Architectural History (9 credit hours)

Art/Arch 1	Art/Architectural History (3)
Arch 2	Architectural History II (3)
Arch 210	20th Century Architecture (3)

Architecture and its intellectual context (9 credit hours)

Arch 107	History of American Architecture (3)
Arch 204	Ancient City and Society (3)
Arch 207	Renaissance Architecture (3)
Arch 209	Architecture 1750-1880 (3)
Arch 213	The City (3)
Arch 342	Architectural Theory (3)
Arch 367	Modernism to Post-Modernism (3)
Art 195	Age of Spirituality (3)
Art 201	Archaeology: Lands of the Bible (3)
Anth 128	Urban Ethnology (3)
Anth 335	Religion, Symbolism and Cosmology (3)
Eco 311	Environmental Economics (3)
Eco 312	Urban Economics (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
Phil 123	Aesthetics (3)
Psyc 373	Sensation and Perception (3)
US 363	Philadelphia: Development of a Metropolis (3)

Architecture and Technology

Arch 147	Building Materials and Methods (3)
Arch 361	Evolution of Highrise Building Construction (3)
Arch 363	Evolution of Long Span Bridges (3)
Arch 365	Evolution of Modern Building Techniques (3)
Arch 351	CAD I (3)
Arch 352	CAD II (3)

For the architecture major it is required that the mathematics requirement be filled with Math 21 & 22; the physical science requirement must be filled with Phys 11 & 12.

For students contemplating graduate studies in architecture, Mech 2 and Mech 12 are recommended.

Undergraduate Courses in Art

Art 1./Architectural History I (3)

Survey of major monuments from Pyramids to Renaissance. Works seen in context of development of design concepts, relation to structural change. Slide lectures. Thomas/Priester

Art 2. Art History II (3) spring

Survey of Western painting and sculpture from Renaissance to present. Priester

Art 7. Basic Design (3) fall-spring

Form and space as foundation for design. Principles and practice of visual expression using line, color, space, mass, value, and texture.

Art 11. Drawing I (3) fall-spring

Concepts and practice of drawing, both traditional and contemporary. Includes drawing from life and an introduction to materials and techniques. Barnstone

Art 13. Sculpture I (3)

Projects directed toward developing design in sculpture. Exploration of materials and their application. Emphasis on sculptural form as it relates to techniques. Gans

Art 20. Color (3) spring, alternate years

Projects directed toward building an awareness of color. Study and observation of the dynamics of color in theory and practice. Redd

Art 23. Life Drawing I (3)

Drawing from the live model as the fundamental experience leading toward an analysis of form in light and space. Emphasis on developing self-expression and on the methods and media of drawing.

Art 37. Printmaking I Relief Printing (3) (fall)

Various techniques are introduced in relief printing: Monoprints, woodcuts and linocuts. Students may elect to do a silkscreen. Materials, tools, processes in creative applications. Prerequisite: Art 11 or consent of chairperson. Redd

Art 38. Printmaking II Intaglio Printing (spring)

Etching, dry point, engraving and collagraph printmaking. Silkscreen option. Prerequisite: Art 11 or consent of chairperson. Redd

Art 43. Graphic Communication I (3) fall

Introduction to basic principles of visual communication that guide the development of creative solutions in graphic, printing, public relations, advertising design. Prerequisite: Art 7. Viera

Art 65. (Psyc 65) Perception and the Visual Arts (3)

Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess

Art 77. Photography I (3)

Introduction to photography as a fine art. Emphasis on interaction of technique, perception and communication in making and responding to photographic image. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: consent of the chairperson.

Art 82. (Clss 82) Art and Archaeology of Greece (3)

The art and architecture of ancient Greece as revealed by archaeology. Brief surveys of the political and cultural backgrounds to the various artistic periods: Bronze Age, Geometric, Orientalizing, Classical, Hellenistic and Roman. Lectures, Slides and films.

Art 111. Drawing II (3)

Projects in creative drawing designed to build on concepts

and practices initiated in basic drawing and life drawing. May be repeated for credit. Prerequisite: Art 11.

Art 113. Sculpture II (3)

Development of principles and techniques in Sculpture I. Modeling, casting, fabrication and carving. Emphasizes an approach to sculptural form and an exploration of the evolution of modern sculpture. Prerequisite: Sculpture I. Gans

Art 121. (WS 121) Women in Art (3)

Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in the art world. Visits to museums and artists' studios. May be repeated for credit as topic varies.

Art 123. Life Drawing II (3)

Advanced drawing from the live model. Prerequisite: Art 23. May be repeated for credit. Staff

Art 135. Painting I (3)

Painting in oil or acrylic oriented toward developing individual creative expression combined with an understanding of the physical nature of the materials. Studio prerequisite: Art 7, 11 or 20, or consent of department chairman. Staff

Art 137. Printmaking III Relief and Silkscreen (fall)

Students can pursue greater depth in relief and silkscreen printmaking. Combo prints. Photo silkscreen processes. Prerequisite: Art 37 and 38. Redd

Art 143. Graphic Communication II (3) spring

Aspects of design are inter-related in function, concept or planning processes. Course emphasizes creativity and problems and solutions in visual communication. Workshops, team work, critiques, conferences. Prerequisite: Art 43 or consent of department chairman. Viera

Art 165. (Psyc 165) Perception and Visual Arts Studio (3)

Projects directed toward exploring relationships between human visual perception and the visual arts. Emphasizes visual thinking and creative problem solving. Prerequisites: Psyc 65, Art 65 or consent of instructor. Shortess

Art 174. (Arch 174, Clss 174, Anth 174) Greek Archaeology (3)

Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small

Art 176. (Arch 176, Clss 176, Anth 176) Roman Archaeology (3)

Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small

Art 177. Photography II (3)

Intensive work in photography as fine art. Advanced study of problems of the photographic images. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: Art 77.

Art 179. History of Photography (1)

Photography as fine art from earliest images to present day. Problems in contemporary photography.

Art 201. (Clss 201) Archaeology: Lands of the Bible (3)

Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and later cultures in the Near East. Material illustrating the cultures and events of the Bible.

Art 218. Romanticism and Realism (2) fall, even years

Painting and sculpture from late 18th-Century Romantic origins to 1860; artists such as Goya, Delacroix, Turner, Friedrich, the Hudson River School, Courbet and Daumier. Redd

Art 220. 20th-Century Art (3)

The development of 20th-Century painting and sculpture from the foundations laid by Cezanne and Van Gogh through the revolutionary movements of cubism, expressionism, surrealism, abstract expressionism, and Pop. Illustrated lectures. Redd

Art 221. Impressionist and Post-Impressionist Painting (2)
fall, even years

Liberation of color in painting; form, emotion and imagination in the Impressionist and Post-Impressionist era. Redd

Art 222. Seminar in Contemporary Art (3)

Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio workshops, readings, discussions and museum visits. Prerequisite: Art 2 or 5. Staff

Art 231. Advanced Design (3)

Directed projects and preparation of portfolio for advanced students in Studio Art and Graphic Communication. Prerequisite: Art 20, 113 or 143. Staff

Art 235. Painting II (3)

Problems in oil, watercolor, acrylic and mixed media. Prerequisite: Art 135. Staff

Art 237. Printmaking IV Collagraph (3)

This course allows students to specialize in collagraph and intaglio print processes. Experimental techniques. Prerequisite: Art 38. Redd

Art 238. Printmaking V Silkscreen Printing (spring)

This course allows students to specialize in silkscreen processes. Photo silkscreen. Prerequisite: Art 137. Redd

Art 252. Advanced Studio Practice (3)

Advanced studio for art or architecture majors under guidance of faculty. Oral and written critiques. Variable media. May be repeated for credit. Prerequisites: Art 7, 11, 37, 135 or consent of department chairman.

Art 269. Special Topics in Art History (3)

Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of the department chairman. Staff

Art 273. Special Topics in Studio Practice (1-4)

Individually directed projects for advanced students capable of undertaking independent creative work in studio art. Prerequisite: consent of the department chairman. Staff

Art 277. Special Topics in Photography (1-4)

Individually directed projects in photography for advanced student capable of undertaking creative work in photography. Prerequisites: Art 77, 177 and consent of department chairman.

Art 321. Graphic Arts Internship (1-4)

Practical in-field experience in graphic communication and graphic arts. Prerequisites: Art 143 and permission of chairman.

Art 335. Painting III (3)

Prerequisite: Art 235 or consent of the department chairman. May be repeated for credit. Staff

Art 337. Printmaking Workshop (3)

Independent experimentation and work in a chosen graphic media for advanced student. Photographic applications, conceptual problems and mixed media. Conferences and critiques. May be repeated for credit. Prerequisites: Art 237 or 238. Redd

Art 350. Special Topics (1-4)

Independent study designed for graduate students in intermediate and advanced graphic communication for curriculum covered by Art 43, 143, 231.

Undergraduate Courses in Architecture**Arch 1. Architectural History I (3)**

Survey of major monuments from the Pyramids to Renaissance. Works seen in context of development of design concepts, relation to structural change. Slide lectures. Fall. Thomas/Priester

Arch 2. Architectural History II (3)

History of American architecture and urbanism from European colonization to the present, from Jamestown to suburbia. Prerequisite: Art/Arch 1 or permission of instructor. Thomas

Arch. 43. Architectural Design I (4)

Fundamental design studio for architecture majors or minors. Composition, spatial concepts; precedent; materials and detail; light and color in architecture. Instruction in basic communication techniques. Prerequisite: Art 7. Viscardi

Arch 103. (Clss 103) Archaeology of Italy (3)

Neolithic, Terramarian, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, through the kingdom, republic, and empire. Survey of Pompeii, Herculaneum and Ostia. Lectures, readings and reports.

Arch 107. History of American Architecture (3) spring

Survey of American building from European colonization to the present. Prerequisite: Art/Arch 1 and Arch 2 or permission of instructor. Thomas

Arch 143. Architectural Design II (6)

Studio format, introductory course in architectural design which introduces students to new ways of thinking about architecture and the perception of space, three-dimensional composition, drawing, and model-making. Previous or concurrent courses in studio art and/or architectural history are recommended. Prerequisite: Arch 43. Zaknic, Corallo

Arch 147. Building Materials and Methods

The primary structural materials — block, wood, steel and reinforced concrete — are examined in their relationship to architectural design. Peters

Arch 174. (Art 174, Clss 174, Anth 174) Greek Archaeology (3)

Ancient Greek cultures from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small

Arch 176. (Art 176, Clss 176, Anth 176) Roman Archaeology (3)

Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small

Arch 204. (Clss 204) Ancient City and Society (3)

Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, and Rome; insights applicable to current urban problems.

Arch 206. The Gothic Cathedral (3)

The architectural form and social context of medieval ecclesiastical architecture in Europe; emphasis on the cathedrals of Chartres, Paris, Amiens, and Reims.

Arch 207. Renaissance Architecture (3)

History of architecture and urban form during the Italian Renaissance. Major architects (Brunelleschi to Palladio), building types (church, palace, and fortress), and urban centers (Pienza, Rome, and Venice).

Arch 209. Architecture and Ideas since 1750 (3)

Examination of philosophical, technological, and cultural forces shaping Western architecture and urbanism

beginning with the Enlightenment. Prerequisites: Art/Arch 1 and Arch 2 or permission of instructor. Thomas

Arch 210. 20th-Century Architecture (3)

History and theory of modern architecture. Analysis of buildings and architects, theories and manifestoes, from industrial revolution to avant-garde movements. Prerequisite: another course in architectural history. Zaknic.

Arch 213. The City (3)

Historical development of modern city. Philosophical, technological, and cultural forces shaping urban experience. Western culture beginning with the Enlightenment. Prerequisites: Art/Arch 1 and Arch 2 or permission of instructor. Thomas

Arch 243. Architectural Design III (6)

Continuation of Arch 143. Design principles of space and form stressed in earlier studios to issues of 'materiality,' 'structure,' 'modes of representation' and the 'process of making.' Prerequisites: Arch 1, 43, 143 and one art studio. Viscardi

Arch 271. Special Topics in Architecture (1-4)

Directed projects for advanced students in architecture or architectural criticism. Prerequisites: Arch 1, 143, Art 11. Major standing in the department or consent of the department chairperson. Student must contact sponsoring professor and complete a contract sheet at preregistration. Staff

Arch 311. Portfolio (1)

The concept, layout, and preparation of a portfolio for graduate school application or employment search, including graphic techniques and reproduction methods. Prerequisite: Art 121 or Art 335 or Arch 243. Staff

Arch 321. Architectural Internship (1-3)

Supervised internship in architectural firm, planning or preservation office. Internship plan must be approved in writing by chairman before it is pursued.

Arch 342. Theory of Architecture (3)

Study of the genesis of form, its representation and its interrelationship to related artistic disciplines. Formal notions will be studied, compared and manipulated through the role of time, scale, perceptual analysis and material transformation. Permission of instructor required. Viscardi

Arch 343. Architectural Design IV (6)

Continuation of Arch 243. The design of buildings and building groups, with the emphasis on urban design and the city. Prerequisite: Arch 1, 43, 143, 210, 243 and one art studio. Staff

Arch 345. Architectural Design V (3)

Undergraduate thesis. An individual design project exploring, with faculty approval, some aspect of architecture of interest to the student. Prerequisite: Architectural Design I-IV; all other courses required for major, previously or concurrently.

Arch 351. Computer Aided Design I (3)

Use and role of computers in architecture. Computer aided design (CAD) system selection and operation, geometric modeling, design knowledge. Practical CAD work on a micro-CAD system through design and drafting of architectural projects. Prerequisite: Arch 143 or consent of chairman. Anderson

Arch 352. Computer Aided Design II (3)

Use of computer aided design as a tool to design and draft in the area of art, architecture, urban design and structures. Advanced hands on experience both early and detailed stages of design using a micro-CAD system. Prerequisite: Arch 351 or consent of chairman. Anderson

Arch 361. (Hist 361) Evolution of Highrise Building Construction (3)

The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. Peters

Arch 363. (Hist 363) Evolution of Long-span Bridge Building (3)

New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. Peters

Arch 365. (Hist 365) Evolution of the Modern Building Process (3)

The criteria of trade — time and money — entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. Peters

Arch 367. Modernism to Postmodernism (3)

Re-examine the central issues facing the great masters of twentieth-century architecture: how they formulated their principles, how they applied them, and how those who inherited the legacy have interpreted it. The major attention will focus on either the great master builders such as Le Corbusier, Mies van der Rohe, Frank Lloyd Wright and Walter Gropius, or on second generation including the transitional figures such as Philip Johnson and other groups: The Whites, Greys, High-Tech, etc. Prerequisite: Art I/Arch I or Art II/Arch II and Arch 210. Zaknic

Arch 388. Advanced Architectural Design (3)

Intensive design projects under a sequence of visiting design instructors. Prerequisites: Arch 210, 243 and consent of the department chairman. Spring. Zaknic

Museum Studies

Art 175. Introduction to Museum Work (3) fall-spring

Introduction to the methods and procedures of research on art objects, historical sites, and documents. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes a research report or equivalent. Prerequisite: consent of the department chairman. Viera

Art 275. Museography and Museology (1-3) fall-spring

Theory and practice in contemporary museums and galleries. Research in the Lehigh University art collection. Curatorial problems in interpretation, display, cataloging and conservation. Each student completes a research report or equivalent. May be repeated for credit. Viera

Art 375. Internship (3) fall-spring

Internship under professional supervision in the principal museum areas: curatorship, conservation, exhibition, interpretation, and administration in association with the Lehigh University Art Galleries, Historic Bethlehem, Inc. and Lehigh County Historical Society. Prerequisite: Art 175, 275 and consent of the department chairman. May be repeated for credit. Viera

Arts and Science

1. or 2. Choices and Decisions (1)

Introduction to decision making with emphasis on curriculum, career planning, and social options. Techniques for using values, family history, and social norms as guidelines for decision making processes. Pass-fail grading.

11. Sex Roles and Society: Continuity and Change (3)

Interdisciplinary study of sex roles — their existing

character and impact upon individuals and institutions: masculine and feminine social roles in fiction; historical attitudes toward marriage and men's and women's work; research on sex differences; ideals of sex equality.

111. The American Character (3)

A chronological and methodological analysis of the shifting conceptions of 'this new man, the American.' Readings are selected from foreign and domestic observers ranging from Crèvecoeur to Christopher Lasch. Special attention is given to the conceptual difficulties of analyzing national character and to the debate over such an analysis. Dowling

Arts-Engineering

The Arts-Engineering program provides the student with an opportunity to experience the breadth of an arts education and simultaneously follow the more focused curriculum of an engineering major. This is a five-year, dual-degree program administered by the College of Arts and Science. An Arts-Engineering graduate is awarded two Bachelors degrees, one from the College of Arts and Science and another from the College of Engineering and Applied Science.

The Freshman year class schedule for an Arts-Engineer includes math, chemistry, physics and English and to this extent is identical to the schedule of a Freshman in the College of Engineering and Applied Science. In addition, each Freshman in the College of Arts and Science is required to enroll in a College Seminar. Selection of a major in the College of Engineering and Applied Science occurs prior to beginning the Sophomore year. A major leading to a degree in the College of Arts and Science should be chosen prior to beginning the Junior year.

Basic Arts-Engineering programs leading to a Bachelor of Arts degree from the College of Arts and Science and a Bachelor of Science degree in an area of engineering are suggested below. The listed courses may be taken in any order if prerequisites are met. Arts-Engineering candidates should recognize that pursuit of a Bachelor of Science degree (e.g., biology, chemistry, biochemistry, earth and environmental science, and math) or a Bachelor of Arts program with larger than average credit requirements (e.g., art, architecture, physical sciences, cognitive science, international careers, among others) will severely restrict choices of free electives. For these students, very careful planning of the academic program is necessary to guarantee completion of all major, distribution and total credit requirements for the two degrees in five years.

The designation AS-courses/electives refers to those courses which meet the major and distribution requirements for the degree in College of Arts and Science. When selected properly, courses which meet distribution requirements in the College of Arts and Science will also satisfy most distribution requirements of the College of Engineering and Applied Science.

Arts-Chemical Engineering

A total of 165 credit hours is needed for the bachelor of arts and the bachelor of science degree.

For the freshman year, see page 25. See electives (b) through (f) for the chemical engineering program on page 26. Careful planning is required so that these may be scheduled during the senior year and fifth year of the program. Any order that does not violate prerequisites is acceptable.

sophomore year, first semester (16 credit hours)

ChE 31	Material and Energy Balances of Chemical Processes (3)
Chem 31	Chemical Equilibria in Aqueous Solutions (3)
Math 23	Analytic Geometry and Calculus III (4)
	AS courses/electives (6)

sophomore year, second semester (18 credit hours)

ChE 44	Fluid Mechanics (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics II Laboratory II (1)
Chem 187	Physical Chemistry I (3)
Math 205	Linear Methods (3)
	AS courses/electives (6)

junior year, first semester (18 credit hours)

ChE 151	Introduction to Heat Transfer (3)
Chem 51	Organic Chemistry I (3)
Chem 53	Organic Chemistry Laboratory I (1)
Chem 192	Physical Chemistry Laboratory (2)
	AS courses/electives (9)

junior year, second semester (17 credit hours)

ChE 244	Mass Transfer and Separation Processes (3)
ChE 210	Chemical Engineering Thermodynamics (4)
ChE 179	Professional Development (1)
Chem 52	Organic Chemistry II (3)
	AS courses/electives (6)

senior year, first semester (18 credit hours)

ChE 201	Methods of Analysis in Chemical Engineering (3)
Chem 189	Physical Chemistry II (3)
	electives for engineering major (6)*
	AS courses/electives (6)

senior year, second semester (18 credit hours)

ChE 211	Chemical Reactor Design (3)
ChE 242	Introduction to Process Control and Simulation (3)
	electives for engineering major (6)*
	AS courses/electives (3)

fifth year

See program description for senior year of chemical engineering, page 89.

*These electives are chosen with the chemical engineering adviser.

Arts-Civil Engineering

A total of 168 credit hours is needed for the bachelor of arts and the bachelor of science degrees. For the freshman year see page 25.

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Mech 2	Elementary Engineering Mechanics (3)
EES 101	Geology for Engineers (3)
	AS courses/electives (6)

sophomore year, second semester (18 credit hours)

Math 205	Linear Methods (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
CE 112	Surveying (4)
	AS courses/electives (6)

junior year, first semester (18 credit hours)

Mech 12	Strength of Materials (3)
Mat 92	Structure and Properties of Materials (3)
CE 15	Graphics for Civil Engineering (3)
	AS courses/electives (9)

junior year, second semester (18 credit hours)

Mech 102	Dynamics (3)
CE 117	Numerical Methods in Civil Engineering (2)
Eco 1	Economics (4)
	AS courses/electives (9)

senior year, first semester (17 credit hours)

CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
CE 159	Structural Analysis I (4)
	AS courses/electives (6)

senior year, second semester (17 credit hours)

CE 160	Structural Design (4)
CE 202	Civil Engineering Planning and Engineering Economics (3)
CE 222	Hydraulic Engineering (4)
	AS courses/electives (6)

fifth year, first semester (18 credit hours)

CE 207	Transportation Engineering (3)
CE 215	Probability and Statistics in Civil Engineering (3)
	Civil Engineering electives (6)
	AS courses/electives (6)

summer

CE 100	Summer Employment (0)
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Eight weeks of summer employment should precede the fifth year.

fifth year, second semester (15 credit hours)

CE 203	Professional Development (2)
CE 270	Water Supply and Wastewater Management (4)
CE 290	Civil Engineering Design Project (3)
	AS courses/electives (6)

Arts-Computer Engineering

A total of 159 credit hours is needed for the bachelor of arts and the bachelor of science degrees. For the freshman year, see page 25.

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
CSc 33	Principles of Computer Engineering (4)
	AS courses/elective (3)

sophomore year, second semester (16 credit hours)

CSc 17	Structured Programming and Data Structures (4)
CSc 261	Discrete Structures (3)
Math 205	Linear Methods (3)
	AS courses/electives (6)

junior year, first semester (16 credit hours)

ECE 81	Principles of Electrical Engineering (4)
Math 231	Probability and Statistics (3)
Math 309	Theory of Probability (3)
	AS courses/electives (9)

junior year, second semester (16 credit hours)

ECE 116	Software Engineering (3)
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ECE 108	Signals and Systems (4)
	AS courses/electives (9)

senior year, first semester (14 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
CSc 262	Programming Languages (3)
	AS courses/electives (6)

senior year, second semester (14 credit hours)

ECE 138	Digital Systems Laboratory (2)
ECE 201	Computer Architecture (3)
	approved elective* (3)
	AS courses/electives (6)

fifth year (36 credit hours)

See program description for senior year of computer engineering, page 142.

*These electives require approval of the department of computer science and electrical engineering. They are subjects in the area of engineering science and design not restricted to offerings of the department.

Arts-Electrical Engineering

A total of 158 credit hours is needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 25.

sophomore year, first semester (15 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
	AS courses/electives (6)

sophomore year, second semester (15 credit hours)

Math 205	Linear Methods (3)
	approved elective* (3)
	AS courses/electives (9)

junior year, first semester (17 credit hours)

ECE 81	Principles of Electrical Engineering (4)
ECE 33	Principles of Computer Engineering (4)
Math 208	Complex Variables (3)
	AS courses/electives (6)

junior year, second semester (16 credit hours)

ECE 108	Signals and Systems (4)
Math 231	Probability and Statistics (3)
	AS courses/electives (9)

senior year, first semester (14 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
ECE 125	Circuits and Systems (3)
	approved elective* (3)
	AS courses/electives (3)

senior year, second semester (17 credit hours)

ECE 126	Physical Electronics (3)
ECE 136	Electromechanics (3)
ECE 138	Digital Systems Laboratory (2)
ECE 202	Introduction to Electromagnetics (3)
	approved elective* (3)
	AS courses/elective (3)

fifth year (36 credit hours)

See program description for senior year of electrical engineering, page 141.

*These electives require approval of the department of

computer science and electrical engineering. Approved electives are subjects predominantly in the area of engineering science and design. They are not restricted to offerings in the department. Students must choose at least one elective in either materials, thermodynamics, fluid mechanics, or physical chemistry, and at least one elective in physics, chemistry, or biology.

Arts-Engineering Physics

A total of 158 credit hours is needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 25.

sophomore year, first semester (15 credit hours)

Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Math 23	Analytic Geometry and Calculus III (4)
	AS courses/electives (6)

sophomore year, second semester (15 credit hours)

Phys 31	Introduction to Quantum Mechanics (3)
Math 205	Linear Methods (3)
	AS courses/electives (9)

junior year, first semester (15 credit hours)

Phys 212	Electricity and Magnetism I (3)
Phys 215	Classical Mechanics I (3)
Math 322	Methods of Applied Analysis I (3)
	AS courses/electives (3)
	electives (3)*

junior year, second semester (18 credit hours)

Phys 213	Electricity and Magnetism II (3)
Phys 190	Electronics (3)
Phys 362	Atomic and Molecular Structure (3)
	AS courses/electives (6)
	electives (3)*

senior year, first semester (17 credit hours)

Phys 260	Laboratory Techniques (2)
Phys 216	Classical Mechanics II (3)
	AS courses/electives (6)
	electives (3)*

senior year, second semester (17 credit hours)

Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 264	Nuclear and Elementary Particle Physics (3)
	AS courses/electives (6)
	electives (6)*

fifth year, first semester (15 credit hours)

Phys 340	Thermal Physics (3)
	AS courses/electives (12)

fifth year, second semester (15 credit hours)

Phys 171	Physics Proseminar (1)
	AS courses/electives (14)

*The electives include at least fourteen credit hours of approved technical electives, including two of the courses Phys 363, 369, (352 or 355), and (346 or 348 or 365). Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives.

Arts-Industrial Engineering

A total of 159 credit hours is needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 25.

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)

Phys 22	Introductory Physics Laboratory II (1)
IE 111	Engineering Probability and Statistics (3)
IE 112	Computer Graphics (1)
	AS courses/elective (3)

sophomore year, second semester (16 credit hours)

IE 121	Applied Engineering Statistics (3)
IE 122	Software Tools (1)
IE 124	Engineering Economy and Decision Analysis (3)
	AS courses/electives (9)

junior year, first semester (15 credit hours)

Math 205	Linear Methods (3)
IE 221	Operations Research-Probabilistic Models (3)
Mat 33	Engineering Materials and Processes (3)
	AS courses/electives (6)

junior year, second semester (16 credit hours)

IE 222	Operations Research-Deterministic Models (3)
ECE 81	Principles of Electrical Engineering (4)
	AS courses/electives (9)
IE 224	Information Systems Analysis and Design (3)

senior year, first semester (16 credit hours)

IE 115	Fundamentals of Modern Manufacturing (3)
IE 116	Manufacturing Laboratory (1)
Mech 2	Elementary Engineering Mechanics (3)
	AS courses/electives (9)

senior year, second semester (16 credit hours)

IE 131	Work Systems and Facilities Planning (3)
IE 132	Work Systems and Facilities Planning Laboratory (1)
ME 104	Thermodynamics (3)
IE	elective (3)*
	AS courses/electives (6)

summer

IE 100	Industrial Employment (0)
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fifth year

See program description for senior year of Industrial Engineering, page 172.

*Note: IE electives must be approved by the department of industrial engineering adviser.

Arts-Mechanical Engineering and Mechanics

A total of 158 credit hours is needed for the bachelor of arts and the bachelor of science degrees. For the freshman year, see page 25.

sophomore year, first semester (16 credit hours)

Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Math 23	Analytic Geometry and Calculus III (4)
ME 10	Graphics for Engineering Design (4)
	AS courses/electives (3)

sophomore year, second semester (18 credit hours)

Mech 2	Elementary Engineering Mechanics (3)
ME 104	Thermodynamics I (3)

Math 205 Linear Methods (3)
AS courses/electives (9)

junior year, first semester (16 credit hours)

Mech 12 Strength of Materials (3)
ME 105 Thermodynamics II (3)
ECE 81 Principles of Electrical Engineering (4)
AS courses/electives (6)

junior year, second semester (14 credit hours)

Mech 102 Dynamics (3)
ME 21 Mechanical Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3)
ECE 162 Electrical Laboratory (1)
AS courses/electives (6)

senior year, first semester (15 credit hours)

Mat 33 Engineering Materials and Processes (3)
Math 208 Complex Variables (3) **or**
Math 231 Probability and Statistics (3)
Mech 203 Advanced Strength of Materials (3)
AS courses/electives (6)

senior year, second semester (15 credit hours)

ME 101 Mechanical Engineering Design I (2)
ME 151 Mechanical Elements (3)
ME 242 Mechanical Vibrations (3)
ME 121 Mechanical Engineering Laboratory II (1)
AS courses/electives (6)

fifth year

See program description for senior year of mechanical engineering & mechanics, page 202.

Arts-Materials Science and Engineering

A total of 161 to 163 credit hours is needed for the bachelor of arts and bachelor of science degrees, depending on the option selected. For the freshman year, see page 25.

sophomore year, first semester (16 credit hours)

Mat 33 Engineering Materials and Processes (3)
Math 23 Analytic Geometry and Calculus III (4)
Phy 21 & 22 Introductory Physics II and Laboratory (5)
Mat 10 Materials Laboratory (1)
AS courses/elective (3)

sophomore year, second semester (15 credit hours)

Mech 2 Elementary Engineering Mechanics (3)
Math 205 Linear Methods (3)
AS courses/electives (9)

junior year, first semester (15 credit hours)

Chem 209 Chemistry of Materials (3)
Mat 203 Structure and Characterization of Materials (3)
Mat 205 Thermodynamics and Phase Diagrams (3)
AS courses/electives (6)

junior year, second semester (16 credit hours)

Mat 204 Processing and Properties of Polymeric Materials (3)
Mat 206 Processing and Properties of Metals (3)
Mat 214 Processing and Properties of Ceramic Materials (3)

ECE 81 Principles of Electrical Engineering (4)
AS courses/electives (3)

senior year, first semester (17 credit hours)

Mat 101 Professional Development (2)
ChE 60 Unit Operations Survey (3)
AS courses/electives (12)

senior year, second semester (15 credit hours)

Mat 216 Diffusion and Phase Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
AS courses/electives (9)

fifth year

See program description for senior year of materials science and engineering, page 190.

Note: Students interested in the industrial or research options should consult with the department chairperson prior to their fourth year. Students selecting the research option should elect Mat 240, Research Techniques, in the second semester of the senior year.

Arts-Master of Business Administration Program

The arts-master of business administration two-degree program is a special opportunity offered by the College of Arts and Science. See Section III for a description.

Asian Studies

The East Asian studies major program is an opportunity in the College of Arts and Science. A description of the program is found in Section III.

Astronomy

Professor. George E. McCluskey, Ph.D. (Pennsylvania), *head.*

Astronomy is offered in the department of mathematics.

1. The Solar System (3) fall

Survey of our knowledge of the solar system. Apollo lunar missions. Mariner missions to Mercury, Venus and Mars. Viking missions to Mars. Missions to Jupiter and Saturn.

2. Stellar Astronomy (3) spring

Survey of our knowledge of stars and stellar systems. Observation and theory of pulsars, quasars, X-ray sources, gamma-ray sources, neutron stars and black holes.

171. Readings (1-3) fall-spring

For nonscience majors to study an area of astronomy more deeply than at the introductory level. Individual supervision. Prerequisites: Astr 1 or Astr 2, and Math 21 or Math 31 or Math 41. May be repeated for credit with the consent of the division head.

211. Stellar Structure and Evolution (3) fall, even-numbered years

Physical processes in stellar interiors. Theory of stellar evolution and interpretation of observations. Binary star evolution. Theory of novae and supernovae. Prerequisites:

Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

221. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundances. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

332. High-Energy Astrophysics (3) spring, odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

342. Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

350. Topics in Astrophysics (3) fall-spring
For science or engineering majors who desire to study an active area of research in astrophysics. Individual supervision. Prerequisites: Astr 2, and Math 23 or Math 32. May be repeated for credit with the consent of the division head.

Behavioral and Evolutionary Biosciences

Professors. David Cundall, Ph.D. (Arkansas); Murray Itzkowitz, Ph.D. (Maryland); John Nyby, Ph.D. (Texas); Martin L. Richter, Ph.D. (Indiana); George Shortess, Ph.D. (Brown); Neal Simon, Ph.D. (Rutgers).

Assistant Professor. Jill Schneider, Ph.D. (Wesleyan).

This division of the Psychology Department offers undergraduate and graduate degrees emphasizing biological aspects of behavior, neuroscience, and evolution. These courses support the major programs in BNS and in Biological Sciences.

Major Programs in Behavioral Neuroscience (BNS) and Biological Sciences (see separate catalog listings)

Undergraduate Courses

BEB 1. Introduction to Biological Adaptation (3) summer
Why species appear, change, become successful, divide into several species, and eventually become extinct. Topics include: the origin and maintenance of variation, population biology, natural selection and speciation. Designed for nonscience majors.

BEB 31. Introduction to the Vertebrates (4)
Evolution, systematics, distribution, behavior and ecology of the major classes of vertebrates, with emphasis on the North American vertebrate fauna. Two lectures, one tutorial, and one lab or field trip.

BEB 134. Comparative Vertebrate Anatomy (4)
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisite: Consent of department.

BEB 151. Vertebrate Field Biology (3)
Field studies on the diversity and distribution of local vertebrates. Emphasis on methods of sampling, collecting and identifying populations and on measurement of the physical environment. Two lectures per week, laboratories on Friday afternoon and on Saturday during the first seven weeks. Prerequisite: Consent of department.

BEB 161. Supervised Research (1-3) fall-spring
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated once for credit. Prerequisite: BEB 31 or BEB 177.

BEB 177. (Psyc 177) Introduction to Behavioral Neuroscience (3)
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: Psyc 1 or BEB 31 or EES 31 or MBio 31.

BEB 225. Introduction to Zoological Research (3)
Literature and methods of research in area of faculty expertise. Requires development of proposal for research to be conducted in the senior year. Fulfills junior level writing requirement. Prerequisites: Junior standing, GPA of 3.0 in major, consent of instructor.

BEB 277. Experimental Neuroscience Laboratory (4)
Nervous system structure; preparation of nervous tissues for microscopic examination; experiments on behavioral assays of nervous system function. Report writing and an independent research project. Fulfills junior level writing requirement. Prerequisites: BEB 177 and consent of department chairperson.

BEB 313. Vertebrate Histology (4)
Microstructural and ultrastructural properties of vertebrate cells and tissues. Techniques of tissue preparation. Two lectures and two labs. Prerequisite: BEB 134.

BEB 314. Vertebrate Development (3)
Germ cell formation, fertilization, early development, and the origin of the principal organ systems. Location, structure, and regulation of information from molecular to organismal levels of organization. Prerequisite: MBio 101 and BEB 134.

BEB 317. Evolution (3)
Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisite: MBio 101.

BEB 329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Consent of department.

BEB 335. (Psyc 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral stimuli, and adaptive value of specific behavior patterns. Prerequisite: Consent of department.

BEB 336. Animal Behavior Laboratory (2)
Experiments and field observations illustrating principles discussed in BEB 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week. Corequisites: BEB 335 or 337.

BEB 337. (Psyc 337) Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisites: Consent of department.

BEB 361. Special Topics (3)

Readings, conferences, and reports on a selected topic not covered in other course offerings. May be taken only once for credit. Prerequisite: BEB 134 and consent of instructor.

BEB 373. (Psyc 373) Sensation and Perception (3) spring
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psyc 65 or 176 or 177. Shortess

BEB 375. (Psych 375) Neuronanatomy of Behavior (3)
Neuronanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: BEB/Psyc 177.

BEB 382. (Psych 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BEB/Psyc 177.

BEB 393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with a faculty sponsor. May be repeated once for credit. Prerequisite: BEB 134 or BEB 277 or Psyc 210.

BEB 395. Thesis (3) fall
Literature review and design of project in selected area. Intended for senior majors in BNS or BEB only. Prerequisite: Consent of faculty sponsor.

BEB 396. Thesis (3) spring
Execution of project designed in BEB 395. Final report and oral presentation. Prerequisite: BEB 395 and consent of faculty sponsor.

For Graduate Students

The BEB division offers two doctor of philosophy degrees; one in Behavioral Neuroscience, and the other in Behavioral and Evolutionary Bioscience.

Research. All graduate students are expected to be involved in research through their graduate careers. There are also several formal research requirements for both Ph.D. programs.

First Year Project. First year students are expected to choose an advisor and begin to work on a research project as early as possible. A written and oral report of the student's research activities is made to the division.

Master's thesis. A master's thesis is required. An oral presentation of the thesis is made to the department. Students entering with a master's degree may submit their thesis in fulfillment of the thesis requirement with faculty approval.

Doctoral dissertation.

Coursework.

Master's requirement. The coursework is envisioned as a two year program requiring 30 hours of credit. At least 24 hours will be coursework taken at the 300 or 400 level with at least two BEB courses taken from the Systematics/Evolution/Environmental Biology Area and two courses from the Physiology/Anatomy/Function Area.

Breadth Requirement. To further ensure that each student will be broadly trained, the 24 hours of coursework at the 300 or 400 level must include specialty courses from at least 3 faculty from within BEB.

Statistics. All students will be required to demonstrate competency in statistics and research design. The actual course requirements will vary according to the specialty interests of the student and will be determined by consultation with the student and his/her supervisor.

Professional Seminar. All students take a one-semester course covering professional issues in teaching, research and ethics during the first semester of the program.

Graduate Seminars. In addition to the breadth requirements for the Master's, Ph.D. students must take a

minimum of 3 additional advanced 400 level seminar courses appropriate to their area of specialization.

General examination. This is required for all doctoral candidates and its primary purpose is to ensure that the student has a thorough grounding in his/her area of specialization.

Graduate Courses

BEB 404. (Psyc 404) Biopsychology (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

BEB 405. Special Topics in Behavioral and Evolutionary Biosciences (1-3)
Readings and discussions on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

BEB 409. Advanced Morphology (3)
A laboratory course in special phases of morphology, such as comparative osteology, comparative morphology or embryology of the vertebrates, etc., to meet the individual interests of the student.

BEB 412. (Psyc 412) Metabolic Influences on Behavior (3)
Sensory systems that detect metabolic energy availability and affect the behavior of humans and other animals: food intake and body weight regulation, sexual and parental behavior, aggression, learning, and body temperature regulation. Prerequisite: BEB 404 and consent of instructor. Schneider

BEB 414. (Psyc 414) Sexual Differentiation (3)
Genetic and hormonal events mediating the development and expression of sexual dimorphisms in physiology and behavior. Current theoretical models; emphasis on biochemical, neuroanatomical and molecular biological considerations. Prerequisite: BEB 404 and consent of instructor. Simon, Nyby, Schneider

BEB 415. (Psyc 415) Psychopharmacology (3)
Mechanism of drug action in the central nervous system, including cell surface receptors and second messenger systems. Drug use/abuse and cellular changes mediating behavioral effects. Drug use in clinical therapy. Prerequisite: BEB 404 and consent of instructor. Simon

BEB 419. Analysis of Reproduction and Mating Systems (3)
Study of reproduction and sexuality in plants and animals with emphasis on current hypotheses as reported in the literature. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Readings from primary source material and review articles. One review paper and one research proposal are required, and together with readings forms the basis for discussion sections and examinations. Prerequisite: Consent of the department chairperson.

BEB 420. (Psyc 420) Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy/neuroendocrinology, and adaptive significance. Prerequisite: BEB 404 and consent of instructor. Nyby

BEB 429. Advances in Herpetology (3)
Lectures and readings from the primary literature on current research in amphibian and reptilian biology. Two lectures, one discussion session and one laboratory or field trip. In addition, a week-long field trip during spring vacation is required. Not open to students who have received credit for BEB 329.

BEB 437. Advanced Behavioral Ecology (3)
Critical evaluation of the theoretical foundation in sociobiology. Emphasis placed on kinship, altruism, mate choice, parental investment, parent-offspring conflict, etc.

Lectures and seminars. Not open to students who have taken BEB 337.

BEB 445. Systematics and Evolution (3)

Theoretical, philosophical and methodological foundations of the classification of eukaryotic organisms and the manner in which systematic theory and method relate to evolutionary theory. Two lectures and one lab-recitation-discussion session. Prerequisite: BEB 317, Cundall

BEB 461. Research (1-9)

Independent research according to the student's preparation and interests. May be repeated for credit.

BEB 472. (Psyc 472) Special Topics in Physiological Psychology (3)

Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: Psyc 404 or consent of department.

BEB 488. Seminar in Neuroscience, Behavior, and Evolution (1)

Advanced seminar in current research developments. May be taken more than once for credit.

Behavioral Neuroscience (BNS)

Professor. John Nyby, Ph.D., Professor of Psychology, *director BNS Program.*

Offering both B.A. and B.S. degrees, this major examines the physiology, genetics and evolution of behavior. An interdisciplinary program, BNS draws upon psychology, biology, chemistry and anthropology with an emphasis on the neurosciences.

B.A. in Behavioral Neuroscience

The B.A. in Behavioral Neuroscience is a natural science major for B.A. distribution purposes.

Required Major Courses

Core Courses

Psyc 1	Introduction to Psychology (4)
EES 31	Introduction to Environmental and Organismal Biology (3)
MBio 33, 31	Introduction to Cell and Molecular Biology (3)
Anth 12	Human Evolution and Prehistory (3)
MBio 101	Genetics (3)
Psyc 110	Experimental Design and Statistical Analysis (3)
Psyc 210	Experimental Psychology (4)
Psyc 177	Introduction to Behavioral Neuroscience (3)
EES 32	Introduction to Environmental and Organismal Biology Laboratory (1) or
MBio 32	Introduction to Cell and Molecular Biology Laboratory (1)

Category 1: take one course

BEB/Psyc 335	Animal Behavior (3)
BEB/Psyc 337	Sociobiology (3)

Category 2: take one course

BEB/Psyc 375	Neuroanatomy of Behavior (3)
BEB/Psyc 382	Endocrinology of Behavior (3)

Category 3: six credits (major electives)

Psyc 77	Drugs and Behavior (3)
Psyc 15-1	Introduction to Clinical Psychology (3)
Psyc 160	Independent Study (1-3)
BEB 161	Independent Research Seminar (1-3)
Psyc 171	Learning Processes and Applications (3)
Psyc 176	Introduction to Cognitive Neuroscience (3)
Psyc 305	Abnormal Psychology (3)
Psyc 353	Personality Theory (3)
Psyc 371	Theories of Learning (3)
BEB/Psyc 373	Sensation and Perception (3)
Psyc 377	Seminar in Physiological Psychology (3)
Psyc/SR 345	Seminar on the Social Evolution of Complex Organizations (3)
BEB 134	Comparative Vertebrate Anatomy (4)
BEB 151	Vertebrate Field Biology (3)
EES 251	Ecology (3)
EES 361	Animal Physiology (3)
EES 351	Aquatic Ecology (3)
BEB 313	General Histology (3)
BEB 314	Developmental Biology (3)
BEB 317	Evolution (3)
BEB 319	Reproduction and Mating Systems (3)
BEB 336	Animal Behavior Laboratory (2)
MBio 356	Human Genetics and Reproduction (3)
MBio 367	Cell Biology (3)
Chem 31	Chemical Equilibria in Aqueous Systems
Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry II (3)
Chem 377	Biochemistry Laboratory (3)

Or courses remaining in categories 1 and 2 (above).

Required Courses in Math and Chemistry

Math 41, 44	BMSS Calculus I and II (6) or
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 51, 52	Organic Chemistry (6)
Chem 53, 58	Organic Chemistry Laboratory I and II (2)

Other Options

The B.A. in Behavioral Neuroscience is a traditional liberal arts degree which can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional math and science, the B.A. also can serve as a preprofessional degree for many graduate and professional schools. Students interested in a particular career-based program should consult their advisor or the program director (Professor John Nyby).

B.S. in Behavioral and Neuroscience

B.S. majors would be required to take the core courses and *all* of the courses listed in category 1 and category 2 of the B.A. program and to fulfill the elective requirements of category 3 of the B.A. program. An early commitment to the B.S. is desirable to meet all the requirements of this program. Additional requirements are shown below.

Math and science requirements for the B.S.

Math 21, 22, 23	Analytic Geometry and Calculus I, II & III (12)
Chem 21, 22	Introductory Chemical Principles & Lab (5)
Chem 51, 52	Organic Chemistry I & II (6)

Chem 53, 58	Organic Chemistry Laboratory (2)
Chem 371 & 372	Elements of Biochemistry I & II (6)
Chem 377	Biochemistry Laboratory (3)
Phys 11, 12	Introductory Physics and Laboratory (5)
Phys 13, 14	General Physics and Laboratory (4)

Phys 21, 22 (5) can substitute for Phys 13, 14.

University and College requirements for the B.S.

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8 or 10	Composition and Literature (3)
Arts and science 1	Choices and Decisions (1)

Nonscience Electives (30) to be broadly distributed in fields of thought other than the natural sciences and mathematics, including at least 12 credit hours each in the humanities and social sciences.

Honors Program in Behavioral Neuroscience

The honors program permits majors of unusual academic ability and interest to explore topics in greater depth than the curricula normally allow. Under faculty supervision, a student normally spends the first semester of the senior year doing library research, learning the appropriate methodology, and preparing a written proposal and oral presentation. In the second semester the proposal is implemented, culminating in a written honors thesis and oral presentation. Successful completion of this program results in "Departmental Honors" being affixed to the student's transcript.

Eligibility requirements. Eligible students must be psychology majors; have completed the first semester of the junior year with an over all GPA of 3.0; and have completed a minimum of four psychology courses with a GPA of 3.3.

Interested students should contact the chairperson.

Biological Sciences

The biological sciences include the study of living systems at levels ranging from the molecular structure and function of specific genes to the complex interactions of organisms with each other and their environment. Lehigh provides courses and curricula spanning this wide range, with designated emphases in molecular biology and genetics, environmental biology and ecology, and behavioral biology.

Major programs are offered in Molecular Biology (Department of Molecular Biology), Behavioral Neuroscience (Department of Psychology), Environmental Science (Department of Earth and Environmental Science), and Biology. The Biology major is coordinated by a committee consisting of faculty members from the three departments listed above, and administrated through the department of molecular biology.

The requirements for the B.A. and B.S. in Biology are listed below, while the other major programs are described in the department listings in this catalog.

B.A. with Major in Biology

College and university requirements

Engl	Composition and Literature (6)
A&S 1	Choices and Decisions (1)
	First year seminar (3)
	Social Sciences (9)
	Humanities (9)

Major Program (47-48 credit hours)

Biology (30 credit hours)

EES 31	Intro. to Environmental and Organismal Biology (3)
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EES 32	Lab Intro. Environmental/Organismal Biology (1)
MBio 31	Intro. to Cell and Molecular Biology (3)
MBio 32	Intro. Cell/Molecular Laboratory (1)
MBio 101	Genetics (3)
MBio 102	Genetics Laboratory (1)
Electives	Biology approved electives (18 credit hours)

Mathematics (6 credit hours)

Math 41	BMSS Calculus I (3)*
Math 44	BMSS Calculus II (3)*

Chemistry/Physics (11 credit hours)

Chm 21	Introductory Chemical Principles (4)*
Chm 22	Chemical Principles Laboratory (1)*
Chm 51	Organic Chemistry (3)

and one of the following:

Chm 31	Chemical Equilibria in Aqueous Systems (3) or
Chm 194	Physical Chemistry for Biological Sciences (3) or
Phys 11	Introductory Physics I (4)

*Although no specific sequence is required, it is recommended that courses marked with an asterisk be completed during the freshman year.

The B.S. in Biology

The Bachelor of Science in biology offers broad scientific preparation in biology to facilitate advanced work in the life sciences. Progression through the program is best served through early commitment.

Requirements for the B.S. in Biology

College and university requirements (28 credit hours)

Engl	Composition and Literature (6)
A&S 1	Choices and Decisions (1)
FS 90	College Seminar (3)
	Social Sciences (9)
	Humanities (9)

Major Program (84 credit hours)

Biology (35 credit hours)

EES 31	Intro. to Environmental/Organismal Biology (3)
EES 32	Lab Intro. Environmental/Organismal Biology (1)
MBio 31	Intro. to Cell and Molecular Biology (3)
MBio 32	Intro. Cell/Molecular Laboratory (1)
MBio 101	Genetics (3)
MBio 102	Genetics Laboratory (1)

one of the following:

EES 162	Non-Vascular Plants (3) or
EES 163	Evolution of Vascular Plants (3) or
BEB 134	Comparative Vertebrate Anatomy (4)

and

EES 251, 252	Ecology and Laboratory (4)
BEB 317	Evolution (3)

and one of the following:

EES 361, 362	Animal Physiology and Laboratory (4) or
MBio 324, 325	Bacteriology and Laboratory (4)
Electives	Biology electives (9)

Mathematics (12 credit hours)

either

Math 21, 22, 23 Analytic Geometry and Calculus I, II, III (12)

or

Math 41, 44, 43 BMSS Calculus I, II and Linear Algebra (9)

and

Math 6, 12 or 231 Intro. to Probability (3), Statistical Methods (3), or Probability and Statistics (3)

Collateral Sciences (37 credit hours)

Chm 21 Introductory Chemical Principles (4)

Chm 22 Chemical Principles Laboratory (1)

Chm 51, 52 Organic Chemistry I and II (6)

Chm 53, 58 Organic Chemistry Laboratory I and II (2)

Chm 31 Chemical Equilibria in Aqueous Systems (3)

Chm 187 or 194 Physical Chemistry I (3)

Phys 11 Introductory Physics I (4)

Phys 12 Introductory Physics Laboratory I (1)

Phys 13 Introductory Physics II-B (3)

Phys 14 Intro. Physics Lab II-B (1)

EES 21 or 11 Intro to Earth Materials & Processes (4) or Environmental Geology (3)

elective any course in the natural sciences or mathematics (3)

and one of the following:

Psyc 1 Introduction to Psychology (3)

Psyc 110 Experimental Design and Statistical Analysis (3)

Phil 128 Philosophy of Science (3)

Recommended B.S. Science Sequence**freshman year**

EES 31 Intro. to Environmental/Organismal Biology (3)

EES 32 Lab Intro. Environmental/Organismal Biology (1)

MBio 31 Intro. to Cell and Molecular Biology (3)

MBio 32 Intro. Cell/Molecular Laboratory (1)

Math 21, 22 Analytic Geometry and Calculus I and II (8) **or**

Math 41, 44 BMSS Calculus I and II (6)

Chm 21, 22 Introductory Chemical Principles and Laboratory (5)

FS 90 College Seminar (3)

A&S 1 Choices & Decisions (1)

sophomore year

MBio 101 Genetics (3)

MBio 102 Genetics Laboratory (1)

Chm 51, 52, 53, 58 Organic Chemistry and Laboratory (8)

Math 23 Analytic Geometry and Calculus III (4)

Math 6, 12 or 231; 43 Probability and Linear Algebra (6)

one of the following:

EES 131 Non-vascular Plants (3) **or**EES 132 Evolution of Vascular Plants (3) **or**

BEB 134 Comparative Vertebrate Anatomy (4)

elective

Psyc 1, Introduction to Psychology (3) or Psyc 110, Psychological Research and Statistics (3) or Phil 128, Philosophy of Science (3)

junior year

EES 21 or 11

Intro to Earth Materials & Processes (4) or Environmental Geology (3)

Phys 11, 12

Introductory Physics I and Laboratory (5)

Phys 13, 14

Introductory Physics II-B and Laboratory (4)

EES 251, 252

Ecology and Laboratory (4)

one of the following:

EES 361, 362 Animal Physiology and Laboratory (4) **or**

MBio 324, 325 Bacteriology and Laboratory (4)

senior year

Chm 31 Chemical Equilibria in Aqueous Systems (3)

Chm 187 or 194 Physical Chemistry I (3)

BEB 317 Evolution (3)

elective Biol electives (6)

elective natural sciences (3)

Minor in Biology

A minor in biology may be achieved by completing the following requirements:

EES 31, 32 Intro. to Environmental/Organismal Biology and Laboratory (4)

MBio 31, 32 Intro. to Cell and Molecular Biology and Laboratory (4)

MBio 101, 102 Genetics and Genetics Laboratory (4)

Chm 21, 22 Introductory Chemical Principles and Laboratory (5)

Chm 51 Organic Chemistry (3)

Math 41 BMSS Calculus I (3)

Elect Biology electives (3)

total credits 26

Special Health Professions Programs

Students may apply for admission to an accelerated B.A.-Doctor of Medicine program and a B.A.-Doctor of Medical Dentistry program. A six-year B.A.-M.D. program is offered in conjunction with the Medical College of Pennsylvania, and a seven-year B.A.-D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a six- or seven-year period. For details concerning admission to these programs, see Health Professions, Section III. Undergraduate courses, please see listings for BEB, EES, and molecular biology.

Chemical Engineering

Professors. Dennis W. Hess, Ph.D. (Lehigh), *chairperson*; Fred P. Stein, Ph.D. (Michigan), *associate chairperson*; Philip A. Blythe, Ph.D. (Manchester, England); Hugo S. Caram, Ph.D. (Minnesota); Marvin Charles, Ph.D. (Brooklyn Polytechnic); John C. Chen, Ph.D. (Michigan), *Carl R. Anderson Professor*; Mohamed S. El-Aasser, Ph.D. (McGill); Christos Georgakis, Ph.D. (Minnesota); James T. Hsu, Ph.D. (Northwestern); William L. Luyben, Ph.D. (Delaware); Matthew J. Reilly, Ph.D. (Illinois); Eric P. Salathe, Ph.D. (Brown); William E. Schiesser, Ph.D. (Princeton), *McCann Professor*; Leslie H. Sperling, Ph.D. (Duke); Andrew Klein, Ph.D. (North Carolina State); Janice A. Phillips, Ph.D. (Pennsylvania); Cesar A. Silebi, Ph.D. (Lehigh); Harvey G. Stenger, Jr., Sc.D. (M.I.T.); Israel E. Wachs, Ph.D. (Stanford).

Assistant professor. Maria M. Santore, Ph.D. (Princeton).

Adjunct professor. William R. Hencke, M.S.E. in ChE (Michigan); Paul M. Mathias, Ph.D. (Florida); Robert G. Sander, B.S. (Lehigh).

Research engineers. Guillermo Elicabe, Ph.D. (Universidad

Nacional del Litoral); E. David Sudol, Ph.D. (Lehigh); Kemal Tuzla, Ph.D. (Technical University of Istanbul).
Emeritus professors. Curtis W. Clump, Ph.D. (Carnegie-Mellon); Arthur E. Humphrey, Ph.D. (Columbia); Leonard A. Wenzel, Ph.D. (Michigan).

Chemical engineers serve a wide variety of technical and managerial functions within the chemical processing industry. For a lifetime of effectiveness they need a sound background in the fundamental sciences of chemistry and physics, a working capability with mathematics, numerical methods, and application of computer solutions, and a broad education in humanities, social sciences, and managerial techniques.

These bases are applied in a sequence of chemical engineering courses in which logic and mathematical manipulation are applied to chemical processing problems.

With the resulting habits of precise thought coupled to a broad base in scientific and general education, Lehigh graduates have been effective throughout industry and in advanced professional education. No effort is made toward any specific industry, but adaptation is rapid and the fundamental understanding forms the base for an expanding career.

The program is also designed to prepare a student for graduate study in chemical engineering. Further study at the graduate level leading to advanced degrees is highly desirable if an individual wishes to participate in the technical development of the field. The increasing complexity of modern manufacturing methods requires superior education for men and women working in research, development, and the design fields or for teaching.

Physical facilities. The Chemical Engineering Department is the only engineering department located on Lehigh's 780-acre Mountaintop Campus. Here the Department occupies approximately one-third of Iacocca Hall, the 200,000-square-foot flagship building that contains offices, classrooms, and laboratories. Additional plant facilities, and the undergraduate chemical processing laboratory occupy approximately 10,000-square-feet in the adjacent IMBT building.

These facilities provide excellent support for a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing units; special equipment for biochemical engineering and for the study of polymers; digital computation for process dynamics study; and special equipment for the study of thermodynamics, kinetics, heat transfer, and mass transfer.

Career Opportunities

Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and management, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids, including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases, have found chemical engineers to be vital to their success. Chemical engineers are also important participants in pollution abatement, energy resources, national defense programs, and more recently in the manufacture of microelectronic devices and integrated circuits.

Special Programs and Opportunities

The department operates a cooperative program that is optional for specially selected students who are entering their junior year. This program affords early exposure to industry and an opportunity to integrate an academic background with significant periods of engineering practice.

The Opportunities for Student Innovation (OSI) program seeks to develop the students' propensity for critical assessment and innovative solution of meaningful problems. The OSI program affords selected seniors an opportunity to experience team research leading toward

technological benefits. Each project is hosted by a company and carried out under the supervision of a Lehigh faculty member. Students register for OSI through ChE 185 and 186.

Chemical Engineering offers specialization certificates in polymer science, biotechnology, and process modeling and control.

Requirements of the Major

freshman year: see Recommended Freshman Year, page 34.

sophomore year, first semester (18 credit hours)

ChE 31	Material and Energy Balances of Chemical Processes (3)
Chm 31	Chemical Equilibria in Aqueous Systems (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Math 23	Analytic Geometry and Calculus III (4)
	elective (3)

sophomore year, second semester (18 credit hours)

ChE 44	Fluid Mechanics (4)
ChE 210	Chemical Engineering Thermodynamics (4)
ChE 179	Professional Development (1)
Chm 187	Physical Chemistry I (3)
Math 205	Linear Methods (3)
	elective (3)

junior year, first semester (18 credit hours)

ChE 151	Introduction to Heat Transfer (3)
ChE 201	Methods of Analysis in Chemical Engineering (3)
Chm 51	Organic Chemistry I (3)
Chm 53	Organic Chemistry Laboratory I (1)
Chm 192	Physical Chemistry Laboratory (2)
	electives (6)

junior year, second semester (18 credit hours)

ChE 242	Introduction to Process Control and Simulation (3)
ChE 244	Mass Transfer and Separation Processes (3)
ChE 211	Chemical Reactor Design (3)
Chm 52	Organic Chemistry II (3)
	electives (6)

senior year, first semester (17 credit hours)

ChE 202	Chemical Engineering Laboratory I (2)
ChE 233	Process/Plant Design (3)
	electives (9)

senior year, second semester (15 credit hours)

ChE 203	Chemical Engineering Laboratory II (2)
ECE 81	Principles of Electrical Engineering (4)
	electives (9)

The total number of credits required for graduation is 134.

A total of 39 credits in electives must be taken. These electives are of six types:

(a) Humanities/Social Sciences: A total of 18 credits of electives in humanities and social science which must include either Eco 11 or Eco 12. (Note that these electives are in addition to the 6 hours of required freshman English).

(b) Approved courses in other engineering departments (CE, EECS, IE, MEM, MAT): A total of 6 credit hours is required. Of these at least 1 credit hour must be in engineering design.

(c) Chemistry: 3 credit hours of 200-level or higher.

(d) Science: 3 credit hours in an approved science course

in the departments of chemistry, physics, mathematics, molecular biology, or earth and environmental sciences.

(e) Chemical Engineering: A total of 3 credit hours is required. At least 1 credit hour must be of engineering design.

(f) Free electives: 6 credit hours in any subject area (including advanced chemical engineering) are required.

(g) Lists of approved science courses and lists showing the engineering design and science credits of all engineering courses are available from the academic advisor in chemical engineering.

Undergraduate Courses

31. Material and Energy Balances of Chemical Processes (3) fall

Material and energy balances with and without chemical reaction. Introduction to phase equilibrium calculations. Applications in chemical process calculations and in design of staged separations: binary distillation, liquid-liquid extraction. Plant trips and special lectures introducing the profession. Prerequisite: Chem 21 or equivalent and Eng 1 previously or concurrently.

44. Fluid Mechanics (4) spring

Fluid mechanics and its applications to chemical processes. Momentum and energy balances in fluid flow. Dimensional analysis. Fluid flow in pipes, packed and fluidized beds. Mixing and agitation. Filtration and sedimentation.

60. Unit Operations Survey (3) fall

The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries.

151. Introduction to Heat Transfer (3) fall

Fundamental principles of heat transfer. Fourier's law. Conduction, convection and radiation. Analysis of steady and unsteady state heat transfer. Evaporation and Condensation. Applications to the analysis and design of chemical processing units involving heat transfer. Prerequisite: ChE 44.

179. Professional Development (1) spring

Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. Prerequisite: junior standing.

185. Undergraduate Research I (3)

Independent study of a problem involving laboratory investigation, design, or theoretical studies under the guidance of a senior faculty member.

186. Undergraduate Research II (3)

A continuation of the project begun under ChE 185. Prerequisite: ChE 185 or consent of the department chairperson.

201. Methods of Analysis in Chemical Engineering (3) fall

Analytical and numerical methods of solution applied to dynamic, discrete and continuous chemical engineering processes. Laplace Transforms. Methods of analysis applied to equilibrium, characteristic value and non-linear chemical engineering problems. Prerequisite: Math 205 previously or concurrently and ChE 44.

202. Chemical Engineering Laboratory I (2) fall

The laboratory study of chemical engineering unit operations and the reporting of technical results. One three-hour laboratory and one lecture period per week. Independent study and both group and individual reporting. Prerequisite: ChE 151.

203. Chemical Engineering Laboratory II (2) spring
Laboratory experience with more complex chemical processing situations including processes involving chemical reactions and those controlled automatically. Prerequisite: ChE 244 and ChE 210.

207. (Math 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall

Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205.

210. Chemical Engineering Thermodynamics (4) spring

Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes. Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: ChE 31.

211. Chemical Reactor Design (3) spring

The application of chemical kinetics to the design and operation of chemical reactors. Plug flow and continuous stirred tank reactors. Homogeneous and heterogeneous reaction kinetics. Design of isothermal and adiabatic reactors. Prerequisite: ChE 151, ChE 210 or equivalent.

233. Process/Plant Design (3) fall

Economic principles involved in the selection of process alternates and determination of process operation costs. Preliminary design of chemical plants including optimization of process configuration, market limitations on plant planning, environmental and regulatory restrictions. Prerequisite: ChE 151 and ChE 210.

242. Introduction to Process Control and Simulation (3) spring

Dynamic simulation of chemical processes. Transfer functions and block diagrams. Introduction to process control equipment. Open loop and closed-loop stability analysis using root locus and Nyquist techniques. Design of control systems. Prerequisite: ChE 2yy, ChE 1xx, and Engr 1.

244. Mass Transfer and Separation Processes (3) spring

Diffusion, fluxes, and component conservation equations. Fick's law. Unsteady state diffusion. Convective mass transfer. Interphase mass transport coefficients. Design of multicomponent distillation, absorption, extraction, and fixed bed processes. Prerequisite: ChE xx and ChE 44.

For Advanced Undergraduates and Graduate Students

301. Process Design (3) fall

Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for nonlinear systems. Effects of uncertainty in process design.

312. (Chem 312, Mat 312) Fundamentals of Corrosion (3) fall

Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Met 210, Chm 187, or equivalent.

320. Waste Water Control (3)

The physical processes of importance in the design of industrial waste-water treatment facilities. Topics will

include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foaming, freezing, and hydrate formation. Prerequisite: ChE 211.

321. Fundamentals of Air Pollution (3)

Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Applied Sciences.

331. Separation Processes (3) spring, every other year

Industrial separation chemistry and processes. Computer solutions for simple and complex multicomponent distillation columns. Azeotropic and extractive distillation. Adsorption, ion exchange and chromatography in packed beds, moving beds and cyclic operation. Synthesis of polymer membrane and its applications to industrial separation processes.

335. (Mat 335) Principles of Semiconductor Materials Processing (3)

Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisites: a course in thermodynamics, and senior standing.

341. Biotechnology I (3) fall

Applications of material and energy balances; heat, mass, and momentum transfer; enzyme and microbial kinetics; and mathematical modeling to the engineering design and scale-up of bio-reactor systems. Prerequisites: Math 22, Phys 11, and Chm 187; or the equivalent of each and the consent of the instructor.

342. Biotechnology II (3) spring

Engineering design and analysis of the unit operations used in the recovery and purification of products manufactured by the biotechnology industries. Requirements for product finishing and waste handling will be addressed. Prerequisite: ChE 341 or equivalent.

350. Special Topics (I-3)

A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

360. (ME 360) Nuclear Reactor Engineering (3)

A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in the College of Engineering and Applied Sciences.

370. Process Safety and Hazard Analysis (3)

A study of the methodology now available for analyzing hazard frequency and level in chemical processes. Applications to real process examples using hazard and operability analysis, fault tree and event tree analysis, "what if" analysis, and preliminary hazard analysis. Also includes a survey of the field of industrial safety.

380. Design Projects (1-6) fall-spring

Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off the campus. The course may be repeated for credit.

386. Process Control (3) fall

Open loop and closed-loop stability analysis using root locus and nyquist techniques, design of feedback controllers with

time and frequency domain specifications. Experimental process identification. Control of multivariable processes. Introduction to sampled-data control theory. Prerequisite: ChE 242 or equivalent.

387. (ECE 387, ME 387) Digital Control (3) spring

Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (2 lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor.

388. (Chem 388) Polymer Synthesis and Characterization Laboratory (3) spring

Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chm 51, 187 or 191.

389. (ECE 389, ME 389) Control Systems Lab (2) spring

Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation; sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: ChE 386, ECE 212, or ME 343.

392. (Chem 392) Polymer Science (3) fall

Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chm 187 or equivalent.

393. (Chem 393, Mat 343) Physical Polymer Science (3) spring

Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: Mat 63 or one year of physical chemistry.

394. (Chem 394) Organic Polymer Science (3) spring

Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and chaingrowth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic free-radical and coordinate catalysis. Prerequisite: one year of physical chemistry and one year of organic chemistry.

Graduate Programs

The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom tailored for individual student needs and professional goals. These individual programs are made possible by a diversity of faculty interests that are broadened and reinforced by cooperation between the department and several research centers on the campus.

A free flow of personnel and ideas between the centers and academic departments insures that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses and seminars to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially sponsored

liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

While the department has interacted with most of the centers on campus, it has had unusually strong and continuing liaisons with Emulsion Polymers Institute, Process Modeling and Control Research Center, Institute for Thermo Fluid Engineering and Science, Environmental Studies Center, Materials Research Center, Center for Surface and Coatings Research, and the Center for Molecular Bioscience and Biotechnology.

In addition to interacting with the centers, the department originates and encourages programs that range from those that are classical chemical engineering to those that are distinctly interdisciplinary. The department offers active and growing programs in: emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities

Master of science and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities

The department is well equipped for research in polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

The Departmental and University computing facilities include 386 and 486-based PCs and RS/6000 workstations, connected by a University-wide high speed network. The central computers in this Unix distributed computing environment include several RS/6000 Model 950 workstations for compute-intensive applications and worldwide networking via Internet. The distributed computing network is expanded as the demand for computing resources and services grows thereby ensuring the Chemical Engineering Department access to the latest computing technology.

Special Programs

Master of engineering design option. For those interested in design, the department offers the master of engineering design option. In this program, the student works on a design project proposed by the process design group of a cooperating industry. Direction of the design project is shared by the cooperating industry and a member of the faculty. Students desiring to enroll in this program should indicate that fact at the time they apply for admission.

Polymer science and engineering. The polymers activity includes work done in the Department of Chemical Engineering as well as the Departments of Chemistry, Materials Science and Physics, the Materials Research Center, the Center for Surface and Coatings Research, the Center for Polymer Science and Engineering, the Emulsion Polymers Institute, and the Polymers Interface Center.

More than 20 faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science and doctor of philosophy degrees in polymer science and engineering.

Research activities in which chemical engineering students and faculty are involved include studies of the mechanism of kinetics of emulsion polymerization and copolymerization, colloidal surface and interfacial aspects of emulsion polymers, and the process involved in their preparation, with special attention to the relationship

between process parameters and properties of polymers; work on polymer blends, especially interpenetrating polymer networks, and the application of these materials to sound-deadening; rheology of viscoelastic materials; crystallization behavior from polymer melts and solutions; polymer film characteristics and the tailoring of these properties for selective transfer rates; latex film drying rates; polymer interdiffusion studies; characteristics of polymer surfaces and interfaces; and the preparation of polymeric materials from agricultural raw materials.

Master of engineering degree. Students may earn the master of engineering degree in chemical engineering upon completion of a course of study and an engineering project meeting all the requirements of the master of science degree. The master of engineering student, however, elects courses closer to engineering practice, and carries out a project of more practical engineering flavor than that of the M.S. candidate. In some cases the project of the master of engineering student will be done in close collaboration with local industry, as noted above.

Major Requirements

The requirements for the master of science degree are listed in the section on The Graduate School. All candidates for the M.S. degree are required to complete a master of science research report for which six hours of graduate credit are earned. Course selection is done individually for each student, although ChE 400 and ChE 415 are required courses.

The requirements for the doctor of philosophy degree also are listed in the section on The Graduate School. In addition to an approved course and thesis program, the Ph.D. student is expected to pass a qualification examination given within the first year of doctoral-level study and to pass a general examination based on a research paper assigned to the student.

Advanced Courses in Chemical Engineering

400. Chemical Engineering Thermodynamics (3) fall Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics. Stein, Santore

401. Chemical Engineering Thermodynamics II (3) spring, every other year

A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacities of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Stein

410. Chemical Reaction Engineering (3) spring

The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: ChE 211.

413. Heterogeneous Catalysis and Surface Characterization (3) fall

History and concepts of heterogeneous catalysis. Surface characterization techniques, and atomic structure of surfaces and adsorbed monolayers. Kinetics of elementary steps (adsorption, desorption, and surface reaction) and overall reactions. Catalysis by metals, metal oxides, and sulfides. Industrial applications of catalysis: selective oxidation, pollution control, ammonia synthesis, hydrogenation of carbon monoxide to synthetic fuels and chemicals, polymerization, hydrotreating, and cracking. Wachs

415. Transport Processes (3)

A combined study of the fundamentals of momentum transport, energy transport and mass transport and the

analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy. Caram, Silebi, Schiesser

419. (Mech 419) Asymptotic Methods in the Engineering Sciences (3)

Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansion. W.K.B. Theory. Far field theories. Blythe

421. Heat Transfer (3)

Analysis of steady and unsteady state transfer. Convection, conduction, and radiation. Vaporization and condensation. Heat transfer in high velocity flow in rarified gases. Applications. Chen

427. (ME 427) Multiphase Heat Transfer (3)

Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ChE 421 or ME 321, or courses in the area of transport phenomena. Chen

428. Rheology (3)

An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows. Silebi

430. Mass Transfer (3) spring

Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Caram, Silebi

433. (ECE 433, ME 433) State Space Control (3) fall

State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: M.E. 343 or E.C.E. 212 or Ch.E. 386 or consent of instructor. Johnson, Georgakis

434. (ECE 434, ME 434) Multivariable Process Control (3)

A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Georgakis

436. (ECE 436, ME 436) Systems Identification (3)

The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-embedding techniques for nonlinear system parameter identification included. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Johnson

437. (ECE 437, ME 437) Stochastic Control (3)

Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor.

438. Process Modeling and Control Seminar (1)

Presentations and discussions on current methods, approaches, and applications. Credit cannot be used for the M.S. degree.

440. Process Design (3)

Synthesis of flow sheets for various processes, investigation of contributions to overall economy of various alternatives. Evaluation of profitability of alternatives.

444. Bioseparations (3) fall, every other year

Separation techniques for biomolecule isolation and purification. Theory and problems of bioaffinity chromatography, electromigration processes, and aqueous two-phase polymer extraction systems. Engineering principles for scaling up bioseparation processes. Prerequisite: Consent of the instructor.

445. Enzyme Engineering (3) fall, every other year

Enzyme characteristics including nomenclature, physical properties, kinetics, and assay methods with emphasis on practical application at commercial scale. Methods of enzyme production and purification. Design and analysis of industrial-scale reactors employing soluble and immobilized enzymes. Prerequisite: Consent of the instructor.

446. Biochemical Engineering Laboratory (3) spring

Laboratory and pilot-scale experiments in fermentation and enzyme technology, tissue culture, and separations techniques. Prerequisites: ChE 341 and ChE 444 or ChE 342 previously or concurrently.

448. Topics in Biochemical Engineering (3) spring, every other year

Analysis, discussion, and review of current literature for a topical area of biotechnology. Course may be repeated for credit with the consent of the instructor. Prerequisite: Consent of the instructor.

450. Special Topics (1-12)

An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

451. Problems in Research (1)

Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

455. Seminar (1-3)

Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

460. Chemical Engineering Project (1-6)

An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

461. Mathematical Methods in Chemical Engineering I (3) fall

Application of ordinary and partial differential equations to the solution of chemical engineering problems with emphasis on chemical reactions and transport processes as they occur in industrial chemical processing. Applications of solution in series, separation of variables, and integral transforms. Prerequisite: Math 322. Caram, Georgakis

464. Numerical Methods in Engineering (3)

Survey of the principal numerical algorithms for: (1) functional approximation, (2) linear and nonlinear algebraic equations, (3) initial and boundary-value ordinary differential equations and (4) elliptic, hyperbolic and parabolic partial differential equations. Analysis of the computational characteristics of numerical algorithms, including algorithm structure, accuracy, convergence; stability and the effect of computer characteristics, e.g., the machine epsilon and dynamic range. Applications of mathematical software in science and engineering. Schiesser

470. Cryogenic Engineering (3)

Liquefaction and separation of gases, physical and chemical principles. Low temperature thermometry. Insulation. Properties of fluids and of structural materials. The behavior of helium. Ultra-low temperature phenomena and theories.

471. Low-Temperature Processes (3)

The problems and design of plants operating in the cryogenic temperature range. Refrigeration demands. Distillation and heat exchange at low temperatures. Analysis of processes for thermodynamic and operating efficiency. Problems of safety, non-steady state behavior and control.

480. Research (3)

Investigation of a problem in chemical engineering.

481. Research (3)

Continuation of ChE 480.

482. (Chm 482, Mat 482) Engineering Behavior of Polymers (3)

A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

483. (Chm 483) Emulsion Polymers (3) fall

Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. El-Aasser, Vanderhoff, Klein

484. (Chm 484) Crystalline Polymers (3)

An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: ChE 392 or ChE 393 or equivalent.

485. (Chm 485, MAT 485) Polymers Blends and Composites (3)

An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are

emphasized. Prerequisite: any introductory course in polymers. Sperling

486. Polymer Processing (3)

Application of fundamental principles of mechanics, fluid dynamics and heat transfer to the analysis of a wide variety of polymer flow processes. A brief survey of the rheological behavior of polymers is also included. Topics include pressurization, pumping, die forming, calendering, coating, molding, fiber spinning and elastic phenomena. Prerequisite: ChE 392 or equivalent. Silebi

492. (Chm 492) Topics in Polymer Science (3)

Intensive study of topic selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

Chemistry

Professors. Kamil Klier, Ph.D. (Czechoslovak Academy of Science, Prague), *university professor and chairperson*; Jack A. Alhadeff, Ph.D. (Oregon Medical School), *director, Institute for Health Sciences and head, division of Biochemical Sciences*; Ned D. Heindel, Ph.D. (Delaware), *Howard S. Bunn Professor of Chemistry*; Charles S. Kraihanzel, Ph.D. (Wisconsin); John W. Larsen, Ph.D. (Purdue); Fortunato J. Micale, Ph.D. (Lehigh); Steven L. Regen, Ph.D. (M.I.T.); Keith J. Schray, Ph.D. (Penn State); *assistant chairperson*; Gary W. Simmons, Ph.D. (Virginia), *director, Zettlemoyer Center for Surface and Coatings Research*; Donald M. Smyth, Ph.D. (M.I.T.), *Paul B. Reinhold professor, and director, Materials Research Center*; James E. Sturm, Ph.D. (Notre Dame); John W. Vanderhoff, Ph.D. (Buffalo), *co-director, Emulsion Polymers Institute*; Daniel Zeroka, Ph.D. (Pennsylvania).

Associate professors. Michael J. Behe, Ph.D. (Pennsylvania); Natalie Foster, Ph.D. (Lehigh); James E. Roberts, Ph.D. (Northwestern).

Assistant professors. John Benbow, Ph.D., (Indiana); Gregory S. Ferguson, Ph.D. (Cornell); Kenneth Haug, Ph.D. (Minnesota); Leonard E. Klebanoff, Ph.D. (California-Berkeley).

Adjunct professors. Robert Eischens, Ph.D. (Northwestern); Michael Ford, Ph.D., (Norfolk, UK); Thomas Hamilton (Wales); Henry Yue, Ph.D. (Pittsburgh); Tibor Sipos, Ph.D. (Lehigh).

Chemistry is a versatile subject area and the pursuit of a career in chemistry can be a most intellectually satisfying experience. No other basic science touches and shapes as many aspects of modern society as does chemistry. From soft contact lenses and synthetic blood to longer-lasting paint and alternative fuel sources, the study of chemistry has provided the solutions to complex problems and has improved the quality of all phases of human life. A particular strength of this department is in Surface and Interface Chemistry that bridges many areas of modern science and technology.

That chemists at all levels of education find a market for their skills and knowledge in every employment area is further demonstration of the breadth of the science of chemistry. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, electronics, agriculture), for service industries (clinical and forensic laboratories, academe, environmental protection, information science) and for governmental positions in regulatory agencies and in science policy analysis. Many chemists are also employed in non-traditional areas—patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor degree holders to study for an advanced degree so

that undergraduate preparation in chemistry enables future study within the discipline of chemistry and in other areas as well. Chemistry or biochemistry is the strongest preparation for graduate studies or professional school in the health-related disciplines (medicine, pharmacology, biochemistry) as well as for other science programs (materials science, polymers, environmental studies, mineralogy).

The study of chemistry opens doors to satisfying careers, to a stimulating view of the world, and to a professional life in which one's natural tendency to ask "why" can lead to personally rewarding endeavors.

The undergraduate curriculum in chemistry contains many of the prerequisites for biology, geological sciences, material science, molecular biology, physics, and chemical engineering, so that students can normally transfer with no loss of credits at least through the sophomore year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:

health-related chemistry (including premedical students)
suggested molecular biology electives: 31, 32, 101, 102, 324, 345, 353, 367.

suggested chemistry electives: 336, 371, 372, 377, 378.

materials chemistry (polymers, solid state, surfaces)
suggested physics electives: 31, 363.
suggested chemistry electives: 312, 388, 392, 393, 394, 395, 396.

environmental chemistry
Suggested earth and environmental sciences 31, 32, 351
suggested molecular biology electives: 31, 32, 101, 102.
suggested chemical engineering electives: 320, 321.
suggested chemistry electives: 303, 395.
suggested civil engineering elective: 374.

geochemistry
suggested electives: 21, 133, 333, 334, 336, 352, 372.
suggested chemistry electives: 303, 337, 396.

chemistry management
suggested accounting electives: 51, 52, 324.
suggested law elective: 201.
suggested management electives: 269, 270, 302, 321 or 333.
suggested economics electives: 105, 119, 145, 229.
suggested marketing electives: 211, 312.
suggested finance electives: 225, 330.

Certain of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

The Five-Year Program

Five year programs are available for students to receive bachelors of science or bachelors of arts degrees and the masters of science degree in chemistry with a concentration in one of several fields of chemistry (inorganic, organic, analytical, physical, polymers, biochemistry, or materials chemistry, the latter has financial aid available.)

B.S. and B.A. Degrees in Chemistry

The Department of Chemistry offers B.S. Chemistry programs in both the College of Arts and Science and the College of Engineering and Applied Science. In addition, the department offers a B.A. chemistry program in the College of Arts and Science. The B.S. chemistry programs in the two colleges are identical in their chemistry and collateral science requirements and are pre-professional in nature. Students planning to attend graduate school in chemistry or an allied science should elect the B.S. program in whichever college they have been admitted. The B.A. program in the College of Arts and Science is not a pre-professional program and may be elected by students who do not plan to do graduate work in chemistry or allied science but wish a stronger background in chemistry than is provided in the Chemistry Minor program. The B.A. program also affords a useful tie-in with health-related chemistry, environmental chemistry, geochemistry or

chemistry management options (see above). Students may transfer from the B.S. to B.A. programs or vice-versa as late as the junior year, since basic requirements are the same for the two. Students who are in the B.A. program and make a late decision to attend graduate school in chemistry or allied science will have minimal chemistry preparation for this by electing Chemistry 307, Advanced Inorganic Chemistry.

Department Modern Foreign Requirement. The modern foreign language requirement is met by one of three options: 1. Completion of the second semester of a modern foreign language; 2. Certification of language equivalent to this level taken in high school; 3. Substitution of six credits of science electives. If science electives are chosen, non-science distribution requirement must still be met.

Bachelor of Science Degree in Chemistry— College of Engineering and Applied Science

freshman year (see page 34) (30-31 credit hours)

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

sophomore year, first semester (16 credit hours)

Chm 51	Organic Chemistry I (3)
Chm 53	Organic Chemistry Laboratory I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Math 23	Analytic Geometry and Calculus III (4)
	modern foreign language requirement (3)* (See details above)

*Chm. 31 Chemical Equilibria will displace this modern foreign language requirement to a subsequent semester if Chem. 31 was not taken in the freshman year.

sophomore year, second semester (16 credit hours)

Chm 52	Organic Chemistry II (3)
Chm 58	Organic Chemistry Laboratory II (1)
Chm 187	Physical Chemistry I (3)
Math 205	Linear Methods (3)
	modern foreign language requirement (3) (See details above)
	Humanities/Social Science requirement (3)

junior year, first semester (15 credit hours)

Chm 192	Physical Chemistry Laboratory (2)
Chm 234	Analytical Chemistry Laboratory (1)
Chm 332	Analytical Chemistry (3)
Chm 341	Chemical Physics and Bonding (4)
Chm 205	Representative Elements (2)
Eco 11 or 12	Economics (3)

junior year, second semester (17 credit hours)

Chm 353	Organic Analysis Laboratory (3)
Chm 307	Advanced Inorganic Chem. (3)
Chm 201	Technical Writing (3)
	Humanities/Social Science requirement (3)
	free electives (6)

senior year, first semester (15 credit hours)

	advanced chemistry elective (3)
	Humanities/Social Science requirement (3)
	free electives (9)

senior year, second semester (14 credit hours)

Chm 338	Advanced Chem. Analysis (2)
	advanced chemistry elective (3)*
	free electives (9)

*This becomes a free elective if the advanced chemistry elective requirement was taken in the fall of the senior year.

Advanced Chemistry Elective Requirement

One 3-credit course selected from the following:

Chm 358	Advanced Organic Chemistry
Chm 371	Elements of Biochemistry I
Chm 376	Advanced Chemistry Research Lab
Chm 381	Radiation and Structure
Chm 382	Spectroscopy and Photochemical Kinetics
Chm 392	Introduction to Polymer Science
Chm 393	Physical Polymer Science
Chm 394	Organic Polymer Science
Phys 363	Physics of Solids

Students are encouraged to take any second course that sequences the first by means of a free elective.

Summary

Total required chemistry hours — 44

Total required physics, mathematics, computer hours — 28

Total required college distribution hours — 24*

Unrestricted elective hours — 27

Program total hour requirement is 123

*The department modern foreign language requirement would normally meet college distribution requirements and be included in the 25 hours. In the event that this is not the case, then unrestricted elective hours will have to be used to meet this modern foreign language requirement.

Bachelor of Science Degree in Chemistry— College of Arts and Science

- I. College and University Requirements — 37 hours
 - a. English 1, 2 — 6 hours
 - b. Arts and Science I — 1 hour
 - c. Non-science electives — 30 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 12 hours each in humanities and social sciences.
- II. Collateral Science Requirements — 28 hours
 - a. Physics 11, 12, 21, 22 — 10 hours
 - b. Mathematics 21, 22, 23, 205 — 15 hours
 - c. Computer Science 11 or Engineering 1 — 3 hours
- III. Required Chemistry Courses — 44 hours
 - a. Introductory Chemistry — Chemistry 75, 76 — 8 hours*
 - b. Organic Chemistry — Chemistry 51, 52, 53 58, 353 — 11 hours
 - c. Inorganic Chemistry — Chemistry 205, 307 — 5 hours
 - d. Physical Chemistry — Chemistry 187, 192, 341 — 9 hours
 - e. Analytical Chemistry — Chemistry 234, 332, 338 — 6 hours
 - f. Technical Writing — Chemistry 201 — 2 hours (W-I course)
 - g. Advanced Chemistry Elective — 3 hours

*The Chemistry 21, 22, 31 sequence may be substituted.

See list of choices for this Advanced Chemistry Elective requirement under the B.S. chemistry program — Engineering College.

- IV. Free Electives — 12 hours (based on 121 total hours)

Model Pattern Roster

freshman year, first semester (15 credit hours)

Arts and Sc 1	Choices and Decisions (1)
Engl 1	Composition and Literature (3)
Chm 75	Concepts, Models, and Experiments I (4)
Math 21	Analytic Geometry and Calculus I (4)
Comp Sci 11 or Engineering 1	Computer Programming (3)

freshman year, second semester (16 credit hours)

Engl 2	Composition and Literature (3)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Math 22	Analytic Geometry and Calculus II (4)
Chm 76	Concepts, Models, and Experiments II (4)

sophomore year, first semester (16 credit hours)

Chm 51	Organic Chemistry I (3)
Chm 53	Organic Chemistry Lab I (1)
Phys 21	Introductory Phys. II (4)
Phys 22	Introductory Phys. II Lab (1)
Math 23	Analytic Geometry and Calculus III (4)
	modern foreign language requirement (3)* (See details above)

*Chm 31 Chemical Equilibria will displace this modern foreign language requirement to a subsequent semester if Chem 31 was not taken in the freshman year.

sophomore year, second semester (16 credit hours)

Chm 52	Organic Chemistry II (3)
Chm 58	Organic Chemistry Lab II (1)
Chm 187	Physical Chem. I (3)
Math 205	Linear Methods (3)
	modern foreign language requirement (3)
	distribution requirement (3)

junior year, first semester (15 credit hours)

Chm 192	Physical Chemistry Lab (2)
Chm 234	Analytical Chemistry Lab (1)
Chm 332	Analytical Chemistry (3)
Chm 341	Chem. Physics and Bonding (4)
Chm 205	Representative Elements (2)
	distribution requirement (3)

junior year, second semester (14 credit hours)

Chm 353	Organic Analysis Laboratory (3)
Chm 307	Advanced Inorganic Chem. (3)
Chm 201	Technical Writing (2)
	distribution requirements — free electives (6)

senior year, first semester (15 credit hours)

	advanced chemistry elective (3)
	distribution requirements — free electives (12)

senior year, second semester (14 credit hours)

Chm 338	Advanced Chem. Analysis (2)
	advanced chemistry elective (3)*
	distribution requirements — free electives (9)

*This becomes a free elective if the advanced chemistry elective was taken in the fall semester of the senior year.

Bachelor of Arts Degree in Chemistry— College of Arts and Science

- I. College and University Requirements — 7 hours
 - a. English 1, 2 — 6 hours
 - b. Arts and Science I — 1 hour
- II. Distribution Requirements (other than above) — 18 hours minimum
 - a. Social Sciences — 9 hours
 - b. Humanities — 9 hours
- III. Collateral Science Requirements — 28 hours
 - a. Physics 11, 12, 21, 22 — 10 hours
 - b. Mathematics 21, 22, 23, 205 — 15 hours
 - c. Computer Science 11 or Engineering 1 — 3 hours
- IV. Required Chemistry Courses — 33 hours
 - a. Introductory Chemistry — Chemistry 75, 76 — 8 hours*

- b. Organic Chemistry — Chemistry 51, 52, 53, 58 — 8 hours
- c. Inorganic Chemistry — Chemistry 205 — 2 hours
- d. Physical Chemistry — Chemistry 187, 192, 341 — 9 hours
- e. Analytical Chemistry — Chemistry 234, 332 — 4 hours
- f. Technical Writing — Chemistry 201 — 2 hours
- V. Free Electives — 35 hours maximum (based on 121 total hours)

*The Chemistry 21, 22, 31 sequence may be substituted.

Model Pattern Roster

freshman year, first semester (15 credit hours)

- Arts and Sc 1 Choices and Decisions (1)
- Engl 1 Composition and Literature (3)
- Chm 75 Concepts, Models and Experiments I (4)
- Math 21 Analytic Geometry and Calculus I (4)
- Comp Sci 11 or Engineering 1 Computer Programming (3)

freshman year, second semester (16 credit hours)

- Engl 2 Composition and literature (fiction, poetry, drama) (3)
- Phys 11, 12 Introductory Physics I and Laboratory (5)
- Chm 76 Concepts, Models, and Experiments II (4)
- Math 22 Analytic Geometry and Calculus II (4)

sophomore year, first semester (16-17 credit hours)

- Chm 51 Organic Chemistry I (3)
- Chm 53 Organic Chemistry Lab I (1)
- Phys 21 Introductory Phys. II (4)
- Phys 22 Introductory Phys. Lab II (1)
- Math 23 Analytic Geometry and Calculus III (4)
- modern foreign language requirement (3-4)* (See details above)

*If Chm 31 was not taken in the freshman year, this course must be taken first semester sophomore year and will displace this modern foreign language requirement to a subsequent semester.

sophomore year, second semester (16-17 credit hours)

- Chm 52 Organic Chemistry II (3)
- Chm 58 Organic Chemistry Lab II (1)
- Chm 187 Physical Chemistry I (3)
- Math 205 Linear Methods (3)
- modern foreign language requirement (3-4)
- distribution requirement (3)

junior year, first semester (15 credit hours)

- Chm 192 Physical Chemistry Lab (2)
- Chm 234 Analytical Chemistry Lab (1)
- Chm 332 Analytical Chemistry (3)
- Chm 341 Chem. Physics and Bonding (4)
- Chm 205 Representative Elements (2)
- distribution requirement (3)

junior year, second semester (14 credit hours)

- Chm 201 Technical Writing (2) (W-I course)
- distribution requirements and free electives (12)

senior year, first semester (15 credit hours)

- distribution requirements and free electives (15)

senior year, second semester (15 credit hours)

- distribution requirements and free electives (15)

Minor in Chemistry

A minor in chemistry may be achieved by completing the following requirements:

- Chm 31 Chemical Equilibria in Aqueous Systems (3)
- Chm 51 Organic Chemistry I (3)
- Chm 53 Organic Chemistry Laboratory I (1)
- Chm 187 Physical Chemistry I (3)
- Chm 192 Physical Chemistry Laboratory (2)
- Chm 332 Analytical Chemistry (3)

Total Credits—15

Necessary pre- or co-requisites for the above would be Chm 21 and 22, Math 21 and Physics 11.

Students who wish to minor in chemistry but whose major program requires any of the above courses may achieve the minor with substitutions approved by the department chairman.

B.S. in Biochemistry

A B.S. Biochemistry major is offered in both the College of Engineering and Applied Science and the College of Arts and Science. The chemistry, biochemistry and collateral science requirements are the same for both programs. These programs are based on the standard freshman year and the normal sophomore year of the B.S. chemistry programs in either college.

Concentration in biochemistry courses takes place in the junior and senior years at the expense of some electives and of two courses in the normal chemistry curriculum.

Consequently, graduates of this program are prepared to go into graduate work in several fields—medicine, biochemistry, chemistry, biophysics, and biology.

This curriculum requires 126 semester-hour credits. Students are expected to meet this total hour requirement unless there are exceptional circumstances.

Bachelor of Science Degree in Biochemistry— College of Engineering and Applied Science

freshman year (see page 34 of current catalog) (30 credit hours)

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students, the Humanities/Social Science elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

sophomore year, first semester (16 credit hours)

- Chm 51 Organic Chemistry I (3)
- Chm 53 Organic Chemistry Lab I (1)
- Phys 21 Intro. Physics II (4)
- Phys 22 Intro. Physics Lab II (1)
- Math 23 Analytic Geometry and Calculus III (4)
- modern foreign language requirement (3)* (See details above)

*Chm 31, Chemical Equilibria, will displace this modern foreign language requirement to a subsequent semester if Chm 31 was not taken in the freshman year.

sophomore year, second semester (16 credit hours)

- Chm 52 Organic Chemistry II (3)
- Chm 58 Organic Chemistry Lab II (1)
- Chm 187 Physical Chemistry I (3)
- Math 205 Linear Methods (3)
- modern foreign language requirement (3)
- biology elective (3)

junior year, first semester (16 credit hours)

- Chm 234 Analytical Chemistry Lab (1)
- Chm 332 Analytical Chemistry (3)

Chm 371	Elem. of Biochemistry I (3)
Chm 377	Biochem. Lab (3)
Eco 11 or 12	Economics (3)
	Humanities/Social Science requirement (3)

junior year, second semester (17 credit hours)

Chm 372	Elem. of Biochemistry II (3)
Chm 353	Organic Analysis Lab (3)
Chm 201	Technical Writing (2)
	Humanities/Social Science requirement (3)
	free electives (6)

senior year, first semester (15 credit hours)

Chm 341	Chemical Physics and Bonding (4)
Chm 192	Physical Chemistry Lab (2)
	biochem, biophys or molecular biology elective (3)
	Humanities/Social Science requirement (3)
	free elective (3)

senior year, second semester (15 credit hours)

Chm 307	Adv. Inorganic Chemistry (3)
	biochem, biophys or molecular biology elective (3)
	free electives (9)

Summary

Total required chemistry hours — 37

Total required biochemistry and biochem/biophys/molecular biology hours — 18*

Total required physics, mathematics, computer hours — 28

Total required college distribution hours — 24**

Unrestricted elective hours — 18

Program total hours requirement is 126.

*The nine credit hours of biochemistry/biophysics/biology electives are chosen with the approval of the adviser.

**The department modern foreign language requirement would normally meet college distribution requirements and be included in the 25 hours. In the event that this is not the case, then unrestricted elective hours will have to be used to meet this modern language requirement.

Bachelor of Science Degree in Biochemistry— College of Arts and Science

- I. College and University Requirements — 37 hours
 - a. English 1, 2 — 6 hours
 - b. Arts and Science 1 — 1 hour
 - c. Non-science electives — 30 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 12 hours each in humanities and social sciences.
- II. Collateral Science Requirements — 28 hours
 - a. Physics 11, 12, 21, 22 — 10 hours
 - b. Mathematics 21, 22, 23, 205 — 15 hours
 - c. Computer Science 11 or Engineering 1 — 3 hours
- III. Required Chemistry Courses — 37 hours
 - a. Introductory Chemistry — Chemistry 75, 76 — 8 hours*
 - b. Organic Chemistry — Chemistry 51, 52, 53, 58, 353 — 11 hours
 - c. Inorganic Chemistry — Chemistry 307 — 3 hours
 - d. Physical Chemistry — Chemistry 187, 192, 341 — 9 hours
 - e. Analytical Chemistry — Chemistry 234, 332 — 4 hours
 - f. Technical Writing — Chemistry 201 — 2 hours (WI course)

*The Chemistry 21/22/31 sequence may be substituted.

- IV. Required Biochemistry Courses and Biochemistry, Biophysics and Molecular Biology Electives — 18 hours
 - a. Biochemistry 371, 372, 377 — 9 hours
 - b. Biochemistry, Biophysics, Molecular Biology Electives — 9 hours minimum*

V. Free Electives — 1 hour (based on 121 total hours)

*The nine credit hours of biochemistry/biophysics/molecular biology electives are chosen with the approval of the adviser.

Model Pattern Roster

Freshman and Sophomore Years

See B.S. Biochemistry — College of Engineering and Applied Science

junior year, first semester (16 credit hours)

Chm 234	Analytical Chemistry Lab (1)
Chm 332	Analytical Chemistry (3)
Chm 371	Elem. of Biochemistry I (3)
Chm 377	Biochem. Lab (3)
	distribution requirements (6)

junior year, second semester (14 credit hours)

Chm 372	Elem. of Biochemistry II (3)
Chm 353	Organic Analysis Lab (3)
Chm 201	Technical Writing (2)
	distribution requirements and free electives (6)

senior year, first semester (15 credit hours)

Chm 341	Chemical Physics and Bonding (4)
Chm 192	Physical Chemistry Lab (2)
	biochem, biophys or molecular biology elective (3)
	distribution requirements and free electives (6)

second year, second semester (14 credit hours)

Chm 307	Advanced Inorganic Chem (3)
	biochem, biophys or molecular biology elective (3)
	distribution requirements and free electives (8)

Undergraduate Courses in Chemistry

5. Chemistry and National Issues

For majors other than science and engineering. Chemistry and current controversies. The atmosphere—global warming, ozone depletion, pollution; water—pollution and treatment; energy—generation and side effects; health—chemicals of life, drugs, carcinogens, personal care; materials—natural and synthetic; food—production and preservation; chemistry—benefits and liabilities. Chm 22 may be taken concurrently for laboratory credit.

21. Introductory Chemical Principles (4) fall-spring

An introduction to important topics in chemistry. These include atomic structure, bonding in inorganic and organic compounds, states of matter, chemical equilibrium, acid-base theories and electrochemistry. Prerequisite: Math 21, 31 or 41 previously or concurrently. Three lectures, one recitation.

22. Chemical Principles Laboratory (1) fall-spring

A laboratory course to be taken concurrently with Chm 21. One three-hour laboratory period per week.

31. Chemical Equilibria in Aqueous Systems (3) fall-spring

A study of the theoretical basis and practical applications of equilibria in aqueous solutions, including acid-base, precipitation-solubility, metal-ligand, oxidation-reduction and distribution equilibria. Introduction to chemical thermodynamics, spectrophotometry, potentiometry and chromatography. The laboratory work emphasizes the qualitative and quantitative analysis of equilibria in aqueous media. Prerequisite: Chm 21, Math 21. Two lectures and one three-hour laboratory period.

51. Organic Chemistry I (3) fall

Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chm 21 or 75.

52. Organic Chemistry II (3) spring

Continuation of Chm 51. Prerequisite: Chm 51.

53. Organic Chemistry Laboratory I (1) fall

Preparation of pure organic compounds. Modern techniques of characterization. Prerequisite: Chm 51 previously or concurrently.

58. Organic Chemistry Laboratory II (1) spring

Continuation of Organic Chemistry Laboratory I. Prerequisite: Chm 53 previously; Chm 52 previously or concurrently.

75. Concepts, Models and Experiments I (4) fall

A first-semester course in chemistry for students planning to major in chemistry or a chemistry-related field. Chemical and physical properties, structures, bonding concepts, and analysis of inorganic substances. Laboratory includes synthesis, separation and analysis procedures; computer applications to chemistry. Three lectures, one laboratory.

76. Concepts, Models and Experiments I (4) spring

Continuation of Chemistry 75. Three lectures, one laboratory. Prerequisite: Chemistry 75 or departmental consent.

187. Physical Chemistry I (3) spring

Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Prerequisite: Chm 31 or 76, and Math 21 or 41 previously or concurrently.

189. Physical Chemistry II (3) fall

A continuation of Chemistry 187. Kinetic theory of gases, statistical thermodynamics, electrolytes in solution, electrochemistry, corrosion, colloid and surface chemistry and the solid state. Prerequisites: Chm 187, Math 23, Phys 21.

192. Physical Chemistry Laboratory (2)

Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chm 187.

194. Physical Chemistry for Biological Sciences (3) fall

The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: Chm 21 or 75.

201. Technical Writing (2)

Principal types of written communications used by professional chemists including informative abstracts, research proposals, progress reports, executive summaries for nonchemist decision makers and proper written experimental procedures, tables, schemes and figures. Prerequisite: junior standing in Chemistry major or consent of the department chairperson.

205. Main Group Elements (2) fall

Chemistry of the main group elements. Prerequisite: Chm 31 or 76.

209. Chemistry of Organic and Inorganic Materials (3) fall

A systematic study of the most important organic and inorganic structures, covering synthesis, nomenclature, reactions, and properties. Grouping of elements with similar properties within the periodic table is stressed. The nature of the covalent bond will be developed. Reactions involving alkenes (especially vinyls), hydroxyl, amine, oxirane, and halogen groups will be emphasized. Crystal structures and physical properties. Prerequisite: Chm. 21 or 75. Sperling, Smyth

234. Analytical Chemistry Laboratory (1) fall

Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chm 332.

250. Special Topics (1-3)

Selected topics in chemistry. May be repeated for credit when different topics are offered.

303. Nuclear and Radiochemistry (3)

A broad survey of nuclear science with particular emphasis on aspects of importance to chemistry and biology. Elementary nuclear theory, production, separation, and identification of radioactive and stable isotopes; use of isotopes in the study of chemical and biological systems; radiological safety; nuclear engineering. Two lectures and one lecture-laboratory. Prerequisite: Chm 187 or Chm 194, or consent of the department chairperson. Sturm

307. Advanced Inorganic Chemistry (3) spring

Introduction to transition metal complexes; theories of bonding; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chm 341.

312. (ChE 312, Mat 312) Fundamentals of Corrosion (3) fall

Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Non-electrochemical corrosion including mechanisms, theories and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings alloys, inhibitors, and passivators. Prerequisite: Met 210 or Chm 187.

332. Analytical Chemistry (3) fall

Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods. Prerequisites: Chm 31 and 51.

336. Clinical Chemistry (3) spring

Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: Chm 332 and 52. Schray

337. (Geol 337, Mat 333) X-ray Diffraction of Materials (3) fall

Emphasis on materials characterization with computer-controlled powder diffractometers. Specific topics include x-ray spectroscopy, crystallographic notation, orientation of single crystals, preferred orientations in polycrystals, crystallite size measurement, phase identification, quantitative analysis of crystalline phases, and stress measurement. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: consent of department chairperson. Lyman

338. Advanced Chemical Analysis (2) spring

A lecture-laboratory course in continuation of Chm 234 and 332 emphasis on spectrochemical, electroanalytical and chromatographic techniques. Prerequisites: Chm 234, 332.

341. Chemical Physics and Bonding (4) fall

Development of ideas relating to the nature of the chemical bond. Emphasis placed on the quantum chemistry of atoms and molecules. Statistical thermodynamics of gaseous and solid systems. Diffraction effects in crystalline solids. Elements of point group theory. Prerequisites: Chm 187, Math 205, Physics 21.

350. Special Topics (1-3)

Selected advanced topics in chemistry. May be repeated for credit when different topics are offered.

353. Organic Analysis Laboratory (3) spring

Identification of organic compounds as single components and mixtures. Application of combined chemical and spectral assay techniques. Use and interpretation of data

from nuclear magnetic resonance, infrared, and mass spectroscopic examinations. Separation techniques for mixtures. Prerequisites: Chm 52 and 58.

358. Advanced Organic Chemistry (3) fall

The study of modern theories of reaction mechanisms and their applications to the problems of organic chemistry. Prerequisite: one year of organic chemistry.

368. Advanced Organic Laboratory (2)

The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory.

371. (MBio 371) Elements of Biochemistry I (3) fall

A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry.

372. (MBio 372) Elements of Biochemistry II (3) spring

Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics and mechanisms, metabolism of carbohydrates, lipids, proteins and nucleic acids, photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chm 371.

375. Research Chemistry Laboratory (1-3) fall-spring

An introduction to independent study or laboratory investigation under faculty guidance. Prerequisite: consent of department chairperson.

376. Advanced Research Chemistry Laboratory (1-6) fall-spring

Advanced independent study or laboratory investigation under faculty guidance. Prerequisite: 3 credits of Chm 375. May be repeated for credit.

377. Biochemistry Laboratory (3) fall

Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: Chm 371, previously or concurrently.

378. Biochemical Preparations (1-3) spring

A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Chm 377 and 372, previously or concurrently.

381. Radiation and Structure (3) spring

Quantum chemistry and group theory applied to molecular orbital theory of bonding, structure, and spectroscopy. Study of selection rules for chemical and photochemical reactions. Prerequisites: Chm 341 and Math 205.

382. Spectroscopy and Photochemical Kinetics (3) spring

Applications of electronic, infrared, and microwave spectroscopy to the study of molecular structure. Chemical consequences of intramolecular excitation; quantum efficiencies and reaction mechanisms; pulse excitation and dynamics of elementary processes. Prerequisite: Chm 341. Lovejoy, Sturm

385. Physical Chemistry of Printing Inks (3) fall

Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Prerequisite: Chm 187 or equivalent. Vanderhoff

388. (ChE 388) Polymer Synthesis and Characterization Laboratory (3) spring

Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential

scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chm 187, 189 or 341 and 51. El-Aasser

392. (ChE 392) Introduction to Polymer Science (3) spring

Introduction to concepts of polymer science. Kinetics and mechanisms of polymerization; synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chm 187 or equivalent. Sperling

393. (ChE 393, Mat 343) Physical Polymer Science (3) fall

Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Sperling

394. (ChE 394) Organic Polymer Science I (3) spring

Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity of monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogenous and heterogenous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisite: one year of physical chemistry and one year of organic chemistry. Vanderhoff

395. Colloid and Surface Chemistry (3) fall

Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chm 187 or equivalent. Micale

396. (Mat 396) Chemistry of Nonmetallic Solids (3) spring

Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chm 187 or Met 210 or equivalent. Smyth

Graduate Programs in Chemistry

The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in chemistry, a doctor of arts in chemistry, master of science and doctor of philosophy degrees in physiological chemistry and a master of science in clinical chemistry. Master of science and doctor of philosophy degrees in chemistry may be obtained by study and research in the following areas of chemistry—analytical, biochemistry, inorganic, organic, physical and polymers. Additional information concerning the physiological chemistry and clinical chemistry programs may be obtained from Section IV of this catalog. The doctor of arts degree includes broad course work in many of the major subdisciplines of chemistry and requires two areas of specialization. A laboratory problem in chemistry (at the M.S. level) and a chemical education project (at the doctoral level) are required. A teaching internship (Chm 411) and an industrial externship are part of the degree program—a program which is particularly intended to upgrade college teachers presently employed in academia but not holding the doctorate.

The Chemistry Department also admits students to the master of science and doctor of philosophy degree programs in polymer science and engineering. These are interdisciplinary programs which are described in Section IV of this catalog and are *not* administered by the chemistry

department. The following information on admissions, proficiency examinations and other policies applies to all of the programs listed above but not to the molecular biology and polymer science and engineering programs.

Admission to graduate study in chemistry assumes that a student has met, or is willing to meet through further study, minimum undergraduate requirements for a bachelor's degree in chemistry. This would include (beyond two semesters of introductory chemistry) two semesters of organic chemistry, two semesters of physical chemistry, two semesters of analytical chemistry and one semester of inorganic chemistry. A promising student whose degree is in a field related to chemistry (e.g., biology, chemical engineering) may be admitted to graduate study in chemistry provided that any deficiencies in basic chemistry preparation are made up in the first year of graduate study and noting that some of the courses required for this may not carry graduate credit.

The Chemistry Department will administer proficiency examinations in analytical, biochemistry, inorganic, organic and physical chemistry to all regular graduate students at the time of matriculation. Each student is required to take three examinations. Information regarding material to be covered on these examinations will be sent to each student several months in advance of matriculation. It is expected that each student will prepare diligently for these tests. A student who performs well on one or more of these tests has an opportunity to take advanced level and special topics courses at an earlier than normal time and may in fact begin graduate research during the first year. A Ph.D. candidate must show proficiency in three areas and an M.S. candidate in two areas within the first year in residence. A student who fails one or more of the proficiency examinations will meet with the department Graduate Coordinator to determine an appropriate course of action in light of the exam performance, projected major and degree aspiration. Two optional routes are available for demonstration of proficiency. (1) The student through self-study and auditing of appropriate courses may prepare for a retaking of a proficiency examination at the beginning of the second semester in residence. (2) Alternatively, the student may enroll in appropriate 300 or 400 level courses during the first year in residence. A grade of B- or better in an appropriate 300-400 level course will be considered equivalent to passing the proficiency examination in that area. Courses taken as a means of demonstrating proficiency will be acceptable on the M.S. or Ph.D. graduate program.

Work for the master's degree requires at least 30 credits—a minimum of 24 course credits and 6 credits of research (which may involve either a laboratory or literature research project). There are no required courses for the M.S., once proficiency has been established. The courses taken are those deemed appropriate for the student's area of concentration. There is a one credit seminar requirement for the M.S. Normally, work for the master's degree can be completed in 1½ calendar years.

Completion of a doctor of philosophy degree program normally requires a minimum of four years full-time work after entrance with a bachelor's degree. There are no specific course credit requirements for the Ph.D.; however, approved degree programs generally have at least 30 hours of course work (including any applied toward a master's degree) and 6 credits of research. Thus, the program consists of approximately one-third formal course work and two-thirds independent study and research. There is a foreign language requirement for the Ph.D. First year college proficiency in one of the four languages—French, German, Russian or Japanese—must be established on some basis. There is also a two credit seminar requirement. After Ph.D. proficiency has been established and the research advisor selected (this must be done by the end of the first year in residence), the major hurdles are the doctoral examinations (both written and oral) in the student's area of concentration which must be passed by the end of 2½ years of residence. If this hurdle is surmounted, the remaining time is spent completing (and ultimately defending) the thesis research under the guidance of the research adviser and the thesis committee.

Most of the chemistry facilities are housed in the 90,000-

square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Most of the research laboratories in the adjacent Sinclair Laboratory are assigned to chemistry professors who specialize in research in surface and colloid chemistry. Biochemistry research is located in Building A of the Mountaintop Campus. Physiological chemistry research is located in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in Whitaker Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Whitaker Laboratory, Sinclair Laboratory, Building A of the Mountaintop Campus, and the Seeley G. Mudd Building.

Current Research Projects

Current research projects of interest are listed below.

Analytical chemistry. NMR studies of organic solids, clinical-biomedical applications, mechanisms of electrode processes, adsorption; redox behavior of transition metal complexes; luminescence of metal-ion complexes in organized media, development of novel immunoassays for clinical diagnosis.

Biochemistry. Characterization of lysosomal glycosidases and glycosyltransferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; synthesis and characterization of novel polynucleotides; sequence dependence of the B-Z transition of DNA; non-isotopic immunoassays; protein surface binding phenomena; development of *in vitro* evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules; relaxation phenomena in NMR and the development of contrast enhancement agents for medical imaging.

Inorganic chemistry. Synthesis, characterization and chemistry of transition metal organometallic complexes with alkyl, carbonyl, nitroso, dinitrogen, dioxygen and phosphine ligands. Addition reactions of the benzene-Cu(I) complex. Applications of molecular mechanics and molecular orbital theories in studies of inorganic and organic derivatives of the representative elements and transition metals. Synthesis of solid catalysts including oxides, sulfides, zeolites and supported metals. Solid state chemistry of dielectric and electro-optic oxides. Defect chemistry and non-stoichiometry of transition metal oxides.

Organic chemistry. Synthesis of medicinal agents, correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; radio pharmaceuticals; organic reactions in molten salts. New hydrogenation reactions. Chemistry of monolayers, liposomes, and total synthesis of biologically active natural products, new synthetic methods, use of radicals in organic synthesis organized molecule assemblages. Coal chemistry.

Physical chemistry. Colloid and surface research include latexes, surface coatings, colloidal stability, adhesion, surface properties of catalysts relating powder flow to their surface chemistry, water at surfaces, fundamental studies of gas-solid surface reactions, printing inks, chemical reactions in small confined volumes, microcalorimetric and FTIR spectrometric studies of Lewis acid-base interactions at interfaces and surface spectroscopy. Solid-state chemistry includes studies of point defects in oxides and oxide growth. Other fields include photochemical dynamics, applications of very high resolution infrared spectroscopy to analytical problems of vibration-rotation lines, nuclear magnetic resonance and applications of quantum mechanics and statistical mechanics to problems of chemical interest. Role of non-covalent bonding in the macromolecular structure of coals. Stabilities of homoconjugated carbocations. Thermodynamics of formation of organic intermediates. Electrostatics of non-aqueous systems. Single crystal

vibrational and electron surface spectroscopy; structure-function relationships in catalysis; intrazeolitic transition metal ion complexes-spectroscopy, structure and reactivity; kinetics of heterogeneously catalyzed reactions.

Polymer chemistry. Synthesis, structure, conformation and properties of high polymers; techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystallization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems; mechanical properties of polymer printing plates; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Major Instrumentation

Special equipment available for graduate research in chemistry is as follows:

Biochemistry facilities—HDL-Cs, GCs, FPLC, ultracentrifuges, DNA synthesizer, scintillation and gamma counters, cold rooms, cell disintegrator, zone and disc electrophoresis apparatus, column chromatograph, auto-clave, ultra-low temperature freezers (-90° and -135° C), rotary vaporator, Milli-Q water purification system, shaking heated water baths. Catalytic high pressure reactors—fully automated with on-line gas chromatographs. Cell culture facilities—complete with optical microscopes having fluorescent and photographic capabilities, liquid scintillation equipment. Coal research and analysis facility—complete with ultracentrifuge, gas chromatographs, gel permeation chromatograph, vapor pressure osmometer, dry boxes. Electron microscope—scanning electron microscope-microprobe. Electrophoresis apparatus—automatic. Ellipsometer. Gas adsorption apparatus. Gas chromatographs, including a PE sigma 3 for inverse gas chromatography. Kinetics apparatus—temperature jump method. Liquid chromatographs—high performance for analytical and preparative work. Microcalorimeter—flowing with UV and refractive index detectors. NMR spectrometers—90 MHz multinuclear Fourier transform, 300 MHz solid state, 500 MHz solution state. Photochemistry equipment—lamps and filters for selected wavelength work. Polarographs and chronopotentiometers—recording multipurpose. Radio-tracer equipment, including a gamma counter. Refractometer—differential. Rheometer—Bohlin VOR. Surface analysis analyzer (BET); 2 automated adsorption instruments. Spectrometers—uv/visible double beam automated, uv/visible/near ir automated, Fourier transform ir with diffuse reflectance and photoacoustic capability, tunable diode laser ir, Raman microprobe, GC mass spectrometer, TOF mass spectrometer with ^{252}Cf desorption source, fluorometers, phosphorescence, electron spin resonance, Auger, Mossbauer, high resolution ESCA, x-ray photoelectron (XPS), low-energy electron diffraction, high resolution electron energy loss, light scattering, electrochemical impedance, photocorrelation for submicron particle analysis. Spectropolarimeter with circular dichroism capability. Tester for power compacts—tensile and compressive. Thermister calorimeter for heats of immersion. Titration equipment—automated and computer interfaced. Vibron elastoviscoimeters.

Graduate Courses in Chemistry

400. Laboratory Safety (0) fall

Accident prevention; emergency response; government regulations; facilities for handling and storage disposal of hazardous materials; emergency facilities; liabilities. Lectures, multi-media presentations, hands-on training by practitioners.

402. Physical Inorganic Chemistry (3) alternate years Aufbau principle and coupling of angular momenta is used to describe atomic and molecular term states. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chm 341 or equivalent. Klier

403. Advanced Topics in Inorganic Chemistry (1-3) alternate years

Topics of contemporary interest in inorganic chemistry. This course maybe repeated when a different topic is offered. Prerequisite: Chm 307 or equivalent.

405. Organometallic Chemistry (3) alternate years

The chemistry of compounds containing carbon to metal bonds. Among topics covered are the following: organic compounds of the representative elements from Group I to IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen complexes; organic synthesis utilizing organometallic catalysts. Kraihanzel

411. Teaching Internship (3-6) fall-spring

The preparation, teaching and grading of one or two undergraduate lecture courses with appropriate supervision by senior faculty members. Observation and evaluation of the intern is effected by classroom visits and videotape review. Prerequisite: candidacy in the doctor of arts program or permission of the department chairperson. May be repeated for credit.

421. Chemistry Research (1-6)

Research in one of the following fields of chemistry; analytical, inorganic, organic, physical, polymer, biochemistry.

423. Bio-organic Chemistry (3) alternate years

An examination of biochemistry on the basis of organic chemical principles. Emphasis on reaction mechanisms of biochemical transformations and methods for elucidation of these mechanisms, i.e., kinetics, isotope effects, exchange techniques, inhibition studies, substrate analog effects and organic model studies. Prerequisite: Chm 358. Schray

424. Medicinal and Pharmaceutical Chemistry (3) alternate years

Principles of drug design, structure-activity relationships in antibacterial, antimalarial, anti-inflammatory and psychoactive drugs; synthesis and modes of action of pharmacologically active agents radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

431. Contemporary Topics in Analytical Chemistry (1)

Discussion of the current literature in analytical chemistry, including spectroscopy, separations, and electrochemistry. Students find current papers and lead discussions. May be repeated for credit.

432. Advanced Analytical Chemistry (3) alternate years

Recent developments in analysis of chemical methods. Statistical methods in analytical chemistry: treatment and interpretation of numerical data; design of experiments; application to and discussion of multistage and other methods for separating chemical species. Prerequisite: Chm 332 or equivalent.

433. Advanced Topics in Electrochemistry (3) alternate years

Theory and applications of selected electrochemical techniques; solutions to mass transport problems, treatment of electron transfer kinetics and kinetics of associated chemical reactions, and critical evaluation of adsorption and other factors associated with electrochemical processes. Prerequisite: Chm 332 or equivalent.

435. Advanced Topics in Clinical Chemistry (3)

Selected areas of clinical chemistry such as chemical toxicology, pathogenic microbial biochemistry in vivo

diagnostic methodology, therapeutic drug monitoring, or other advanced topics. May be repeated for credit when a different topic is offered.

436. Special Topics in Analytical Chemistry (1-3)

Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered.

437. Pathophysiological Chemistry (3) spring

Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chairperson. Alhadeff

441. Chemical Kinetics (3) alternate years

A study of kinetic processes. Phenomenological chemical kinetics; order, mechanism effect of external variables on rate. Theories of the rate constant. Relation between thermodynamics and kinetics. Applications to selected systems such as unimolecular decompositions, molecular beams and diffusion-limited processes. Prerequisite: one year of physical chemistry. Sturm

443. (Mat 443) Solid-State Chemistry (3) alternate years

Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

445. Elements of Physical Chemistry (4)

Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics. Prerequisite: Chm 341 or its equivalent.

451. Physical Organic Chemistry (3) alternate years

An introduction to quantitative organic chemistry including relationships between structure and reactivity, medium effects on reactions, introduction to orbital symmetry effects in organic reactions, and reaction mechanisms. Prerequisite: Chm 358 or consent of department chairperson. Larsen

453. Heterocyclic Compounds (3) alternate years

An intensive study of the syntheses, reactions and properties of heteroaromatic compounds including derivatives of thiophene, pyrrole, furan, indole, pyridine, quinoline, the azoles and the diazines — all considered from the viewpoint of modern theories of structure and reaction mechanisms. Prerequisite: Chm 358.

455. Organic Synthesis (3) alternate years

Principles of organic synthesis; retrosynthetic analysis, convergent vs. linear sequences, control of relative stereochemistry, chiral substrates and reagents. These and other principles will be illustrated using examples from the recent literature. Prerequisite: Chm 358 or consent of department chairperson.

458. Topics in Organic Chemistry (3)

An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

466. Advanced Organic Preparations (2-3)

A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

467. Principles of Nucleic Acid Structure (3) alternate years

An examination of the principles underlying nucleic acid structure including stereochemistry, electrostatics, hydration, torsional constraints, dequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chairman. Behr

468. Principles of Protein Structure (3) alternate years

An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chairman. Behr

469. Biochemical Problem Solving I (1) fall

Applications of material covered in Chm 371 including techniques used in research. Prerequisite: Chm. 371 previously or concurrently.

470. Biochemical Problem Solving II (1) spring

Applications of concepts covered in Chm 372 including techniques used in research. Prerequisite: Chm 372 previously or concurrently.

471. Eucaryotic Biochemistry (3) alternate years

Biochemistry of selected eucaryotic processes including hormone chemistry, blood clotting, immunochemistry, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: Chm 372 or consent of department chairperson. Lowe-Krentz

472. Lipids and Membranes (3) alternate years

structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: Chm 372 or consent of department chairperson. Lowe-Krentz

473. Biochemistry of Complex Carbohydrates (3) alternate years

Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants. Alhadeff

475. Advanced Topics in Chemistry (1)

Audiovisual courses in topics such as acid-base theory, NMR, chromatography, electroanalytical chemistry and mass-spectroscopy interpretation; course material obtained from the American Chemical Society. May be repeated for credit.

477. Topics in Biochemistry (1-3)

Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chairperson.

479. Biochemical Techniques (3)

Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chm 371 or its equivalent previously or concurrently.

480. Advanced Biochemical Preparations (1-3)

An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chairperson.

481. Chemistry Seminar (1-6)

Student presentations on current research topics in the student's discipline but not on subjects close to the thesis. A one-hour presentation and attendance at other presentations are required for credit. May be repeated for credit, up to six times.

482. (ChE 482, Mat 482) Engineering Behavior of Polymers (3) spring

Mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior. Robinson

483. (ChE 483) Emulsion Polymers (3) fall

Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. Prerequisite: previous course in polymers. Vanderhoff

484. (ChE 484, Mat 484) Crystalline Polymers (3) spring

Morphology and behavior of both polymer single crystals and bulk crystallized system. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties.

485. (ChE 485, Mat 485) Polymer Blends and Composites (3) fall

Synthesis, morphology and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforce polymers are emphasized. Prerequisite: any introductory course in polymers. Sperling

487. Topics in Colloid and Surface Chemistry (3)

Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. May be repeated for credit as different topics are covered. Prerequisite: Chm 395. Micale, Vanderhoff

488. Advanced Topics in Physical Chemistry (1-3)

Advanced topics in physical chemistry, such as photochemistry and molecular beam dynamics, Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance, liquids and solutions. May be repeated for credit when different topics are offered.

489. (ChE 489) Organic Polymer Science II (3) alternate years

Continuation of Chem 394. Theory and mechanism of ionic vinyl-addition chain-growth polymerization. Chain copolymerization by radical and ionic mechanisms. Mechanism of ring-opening polymerization. Stereochemistry of polymerization including ionic, coordination, and Ziegler-Natta mechanisms. Reactions of polymers, including crosslinking, reaction of functional groups, graft and block copolymers, and polymer carriers and supports. Prerequisite: Chm 394 or equivalent. Vanderhoff

491. Physical Chemistry of Organic Polymer Coatings (3) alternate years

Pigment/bonder geometry. Oil absorption of pigments. Critical Pigment Volume Concentration concept. Pigment dispersion including surface tension, capillarity, works of dispersion, transfer and flocculation, and dispersing-mixing equipment. Solubility parameter concept. Coating viscosity and viscometers. Evaporation of solvents including water. Coating rheology, mill base letdown, and pigment settling. Film application including leveling, sagging, slumping and draining. Prerequisite: Chm 393 or 394 or equivalent. Vanderhoff

492. (ChE 492) Topics in Polymer Science (3)

Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chm 392 or equivalent.

493. Organic Chemistry of Organic Polymer Coatings (3) alternate years

Film formation from solution and dispersion, and application of coatings. Mechanism and kinetics of curing glyceride oils, varnishes and alkyd resins, unsaturated polyesters, thermoplastic cellulose, acrylic and vinyl resins, epoxy resins, polyurethanes, amine- and phenol-formaldehyde resins, thermosetting vinyl and acrylic copolymers, water-based systems, natural and synthetic rubber, and silicone resins. New solventless coatings. Prerequisites: Chm 393 and 394 or equivalent. Vanderhoff

494. Quantum Chemistry (3) alternate years

Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: Chm 445 or consent of the department chairperson. Zeroka

495. Statistical Thermodynamics (3) alternate years

Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: Chm 445 or consent of the department chairperson. Zeroka

Chinese

See listings under Modern Foreign Languages.

Civil Engineering

Professors. Irwin J. Kugelman, Sc.D. (M.I.T.), *chairman*; George C. Driscoll, Ph.D. (Lehigh); Hsai-Yang Fang, Ph.D. (West Virginia); John W. Fisher, Ph.D. (Lehigh), *director*, *NSF-ERC Advanced Technology for Large Structural Systems*; Ti Huang, Ph.D. (Michigan); Robert L. Johnson, Ph.D. (Iowa State); Celal N. Kostem, Ph.D. (Arizona); Le-Wu Lu, Ph.D. (Lehigh); Alexis Ostapenko, Sc.D. (M.I.T.); Robert M. Sorensen, Ph.D. (U.C. Berkeley); David A. VanHorn, Ph.D. (Iowa State); John L. Wilson, Ph.D. (Pittsburgh); Ben-Tsung Yen, Ph.D. (Lehigh).

Visiting professor. Johannes H. Egbers, Ing. (HTS. Arnhem).

Associate professors. Kazuhiko Kasai, Ph.D. (U.C. Berkeley); Gerard P. Lennon, Ph.D. (Cornell); Peter Mueller, Dr. sc. techn. (ETH, Zurich); Sibel Pamukcu, Ph.D. (L.S.U.); James M. Ricles, Ph.D. (U.C. Berkeley); Arup K. Sengupta, Ph.D. (Houston); Richard N. Weisman, Ph.D. (Cornell).

Assistant professors. Stephen P. Pessiki, Ph.D. (Cornell); Richard Sause, Ph.D. (U.C. Berkeley); E. Sarah Slaughter, Ph.D. (M.I.T.).

Active emeritus. Lynn S. Beedle, Ph.D. (Lehigh).

Civil engineering occupies a prominent position as one of the major fields in the engineering profession. Civil engineers are concerned with all aspects of the conception, planning, design, construction, operation, and maintenance of major physical works and facilities that are essential to modern life. Civil engineering projects are typically characterized by extreme size, complexity, durability, and cost. Examples include bridges, buildings, transportation

facilities, tunnels, coastal facilities, dams, foundations, waterways, sewerage and sewage treatment facilities, and water supply and purification systems.

The undergraduate program includes a strong base of mathematics and the physical sciences, followed by a broad range of courses in the areas of engineering science and civil engineering analysis and design. In civil engineering, the courses extend across the areas of structural, geotechnical, hydraulic, environmental, and transportation engineering, along with planning, economics, probability and statistics, and surveying and measurements. The program is enriched with a series of required and elective courses in the humanities and social sciences. In addition, there are a number of elective opportunities to enable students to pursue areas of particular interest. Over the entire curriculum, emphasis is placed on the development of a solid knowledge of civil engineering fundamentals. Concomitantly, the program is threaded with instruction and opportunities in utilizing the computer, including computer graphics, throughout the field of civil engineering.

The civil engineering program prepares individuals for entry into the engineering profession or for entry into high quality programs of graduate study. With proper selection of electives, students may also prepare for entrance into schools of law or medicine, or into master's-level programs in engineering management or business administration.

For students interested in geological engineering, a five-year program is available, leading to two bachelor of science degrees, in civil engineering and in earth and environmental sciences.

Recommended Sequence of Courses

freshman engineering year (see page 34)

sophomore year, first semester (17 credit hours)	
Math 23	Analytic Geometry and Calculus III (4)
EES 101	Geology for Engineers (3)
Mech 2	Elementary Engineering Mechanics (3)
CE 112	Surveying (4)
Eco 11 or 12	Micro- or Macroeconomics (3)

sophomore year, second semester (17 credit hours)	
Math 205	Linear Methods (3)
Mech 12	Strength of Materials (3)
CE 15	Graphics for Civil Engineering (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
HSS	Humanities/Social Sciences Elec. (3)

junior year, first semester (17 credit hours)	
Mech 102	Dynamics (3)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
CE 159	Structural Analysis I (4)
HSS	Humanities/Social Sciences Elec. (3)

junior year, second semester (17 credit hours)	
CE 117	Numerical Methods in Civil Engineering (2)
CE 160	Structural Design (4)
CE 202	CE Planning and Engineering Economics (3)
CE 222	Hydraulic Engineering (4)
CE 270	Water Supply and Wastewater Management (4)

summer	
CE 100	Summer Employment (0)

senior year, first semester (18 credit hours)	
Mat 192	Structure and Properties of Materials (3)
CE 207	Transportation Engineering (3)

CE 215	Probability and Statistics in Civil Engineering (3)
HSS	Humanities/Social Sciences Elec. (3)
	Approved Elective (3)
	Free Elective (3)

senior year, second semester (17 credit hours)	
CE 203	Professional Development (2)
CE 290	CE Design Project (3)
HSS	Humanities/Social Sciences Elec. (3)
	Approved Electives (6)
	Free Elective (3)

Elective opportunities total 30 credit hours. The selection of elective courses is to be in consultation with student's academic adviser in the department of civil engineering. A total of 133 credit hours is required for the degree in civil engineering.

Undergraduate Courses

15. Graphics for Civil Engineering (3) fall, spring
Basic theoretical and technical study of computer graphics systems with practical applications in civil engineering. Theory of orthographic and perspective projection. Problems of point, line and plane in descriptive geometry. Emphasis on visualization and geometric logic. Prerequisite: Engr 1.

100. Summer Employment (0)

During the summer preceding the senior fall semester, students spend at least eight weeks in practical work, preferably in the field that the individual plans to enter after graduation. A letter from the employer confirming the dates of employment is required. Prerequisite: senior standing.

104. Readings in Civil Engineering (1-3)

Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the department chairperson.

112. Surveying (4) fall, spring

Principles of plane surveying theory and practice applicable to land, engineering, topographic, and control surveys, including the influence of systematic and random errors in field and office measurements, calculations, drawings, and maps. Use of field and office equipment. Field astronomy. Horizontal, vertical, and spiral curves. Prerequisite: Math 21 previously or concurrently or consent of the department chairman.

117. Numerical Methods in Civil Engineering (2) spring

Techniques for computer solution of linear and non-linear simultaneous equations; eigenvalue analysis; finite differences; numerical integration; numerical solutions to ordinary differential equations. Case studies in the various branches of Civil Engineering. Prerequisites: Engineering 1, Math 205.

121. Mechanics of Fluids (3) fall

Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamics similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 2.

140. Special Topics in Surveying (3) spring

Geodetic coordinates, map projections, triangulation, photogrammetry, construction surveys, hydrographic surveys, underground surveys, adjustment of horizontal and vertical control nets, precise leveling, doppler satellite surveys, and aerial pollution control surveys. Field and office work. Prerequisite: CE 112. Limited enrollment.

143. Soil Mechanics (4) fall

Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Identification;

classification; permeability; effective stress and pore water pressures; compaction, compression and consolidation; stress-strain behavior and shear strength; laboratory tests for engineering properties; application of theories and principles in engineering practice. Prerequisite: Mech 12 or consent of the department chairperson.

158. Structural Laboratory (2) spring
Study of behavior of simple structural members. Planning, testing, and reporting. Acquisition, analysis, and presentation of experimental data. Steel, reinforced concrete, and other materials. Prerequisites: CE 160 and Mat 92, previously or concurrently.

159. Structural Analysis I (4) fall
Elastic analysis of statically determinate beams, frames, and trusses; deflections by the methods of virtual work and moment area; influence lines for determinate structures; modeling for structural analysis; flexibility, stiffness, and approximate methods of analysis of indeterminate structures. Prerequisite: Mech 12.

160. Structural Design (4) spring
Principles of structural design. Safety and economy. Strength, stability and serviceability criteria. Selection of simple structural members to resist tensile, compressive, bending, and shearing loads. Various structural materials will be covered, especially steel and reinforced concrete. Prerequisite: CE 159.

172. Fundamentals of Environmental Pollution (3)
Introduction to water, air, noise, solid waste, radiation and hazardous substance pollution problems. Regulatory standards and rationale, risk and hazardous assessment, economic consequences, technology for control.

202. CE Planning and Engineering Economics (3) spring
The planning and management of civil engineering projects. Modeling and optimization methods, project management techniques. Financial decision-making among alternatives. Present value and discounted cash flow analysis; incremental analysis and rate-of-return criteria.

203. Professional Development (2) spring
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies. Prerequisite: consent of the department chairperson.

205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chairperson.

207. Transportation Engineering (3) fall
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CE 112 and senior standing.

211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chairperson.

215. Probability and Statistics in Civil Engineering (3) fall
Basic concepts of probability; probability distributions; estimation of parameters; regression and correlation. Analysis of stochastic engineering data. Emphasis on applications to civil engineering problems; structural stability, random loading, risk analysis, traffic flow and water-resource problems, hazard assessment for toxic materials. Prerequisites: Math 23, Mech 12, previously or concurrently.

217. Computer Integrated Civil Engineering Systems (3) spring
Basic characteristics of modern interactive analysis and design systems. Data structures; 2-D and 3-D graphics modeling; user interfaces; integrated analysis/graphics/

data management. Decision tables. Introduction to Knowledge Based Systems and Artificial Intelligence. Numerous case studies and use of interactive systems. In depth experience with computer-integrated systems.

222. Hydraulic Engineering (4) spring
Flow measurements, pipe hydraulics, open-channel flow and river engineering, hydraulic structures and model studies. Laboratory experiments in applied hydraulics. Prerequisite: CE 121.

223. Hydraulics for Earth and Environmental Scientists (3) spring, alternate years
Basic fluid mechanics and hydraulics for non-engineers. Topics include: fluid statics; conservation of mass, energy and momentum; boundary layer flow and fluid drag; flow in pipelines and pumps; open channel flow; groundwater flow; hydrologic analysis; and coastal processes. Prerequisite: Basic courses in calculus and physics.

244. Foundation Engineering (3) spring
Application of the theories and principles of soil mechanics to foundation design. Site investigations and engineering tests to evaluate subsoil conditions. Bearing capacity and settlement analyses for building foundations. Lateral loads on retaining walls and bulkheads. Prerequisite: CE 143 or consent of the department chairperson.

259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-sway and nonprismatic members. Influence lines for determinate and indeterminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer library programs. Prerequisite: CE 159.

261. Structural Steel Design (3) fall
Design of steel structures, including plate girders, other built-up members, trusses, frames, grillages, shell-type structures and thin-gage members. Additional topics include connections, composite beams, and fatigue and fracture concepts related to structural design. Prerequisite: CE 160.

263. Structural Concrete Design (3) fall
Design of reinforced concrete structural members and simple systems, including continuous beams, columns, frames, one-and two-way slabs, and footings. Deflection, cracking, and column slenderness. Introduction to prestressing and torsion. Prerequisite: CE 160.

266. Project Management (3)
An overview of the management and control of engineering ventures and projects. Emphasis on systems theory, life-cycle approach, resource management, financial controls, contracts, labor relations and organizational forms. Case studies and lectures from industry. Prerequisite: CE 202 or consent of the department chairperson.

270. Water Supply and Wastewater Management (4)
Quantitative and qualitative evaluation of water sources. Transport, storage, purification and distribution of water supplies. Analysis and design of systems for collection and management of spent and excess storm water; wastewater treatment processes for return to the natural ecosystem. Field trips to water and wastewater process facilities. Laboratory determination of water quality parameters and wastewater characterization for incorporation into management practice. Prerequisites: Chem 21, 22 and CE 121.

281. Special Topics (1-6)
A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chairperson.

290. CE Design Project (3) spring
Supervised design projects applying the fundamentals of engineering science and the concepts of planning and systems analysis in the design of practical engineering works.

The scope includes needs analysis, formulation of the design problem statement and evaluative criteria; analysis of alternative solutions and the generation of specifications. Economic, social, environmental, aesthetic and safety constraints are considered. Practicing professional engineers are invited to serve as consultants. Written and oral reports are required. Prerequisite: Senior Standing.

320. Flood Hydrology and Hydraulics (3) fall
Rainfall-runoff analysis, overland flow, hydrograph theories, modeling. Frequency analysis of extreme events. Flood routing. Design storms. Floodplain hydraulics, floodplain delineation. Prerequisite: CE 222. Weisman

321. Advanced Hydraulics (3) fall
Energy and momentum concepts, frictional resistance in open channels and closed pipelines. Rapidly and gradually varied flow in open channels; unsteady flow in open channels and closed pipelines. Prerequisite: CE 222.

322. Hydromechanics (3)
Ideal fluid flow, vortex flow, creeping motion; laminar boundary layers, turbulent shearing stress and turbulent boundary layers; turbulent jets and diffusion. Prerequisites: Math 205 and CE 222.

324. (Mech 323) Fluid Mechanics of the Ocean and Atmosphere (3)
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121.

326. Engineering Groundwater Hydrology (3) spring
The study of subsurface water, its environment, distribution, and movement. Also included are hydraulics of pumping wells, sea water intrusion, artificial recharge, and an introduction to the movement of contaminants. A design project is included to simulate drawdown and movement of contaminants in a regional aquifer using a finite-difference model. Prerequisite: CE 222. Lennon

335. Coastal Engineering (3) fall
Linear wave theory and wave characteristics; survey of nonlinear theories; tides, tsunamis, storm surge and basin resonance; wind-generated wave spectra, statistics and forecasting; wave-structure interaction; nearshore circulation and sediment transport; interaction of littoral processes with structures. Prerequisite: CE 121. Sorensen

336. Harbor and Coastal Engineering Design (3) spring
Functional and structural design of breakwaters; groins, revetments and other coastal structures; shoreline stabilization; harbor entrance navigation, hydraulics, and stabilization; layout of harbors and marinas; dredging and sediment bypassing; design of marine outfalls and intakes. Prerequisite: CE 335. Sorensen

341. Ground Improvement Engineering (3) spring
The mechanisms of soil stabilization; principles and techniques; grouting and injection methods; reinforced earth methods, dynamic consolidation; deep compaction; sand drains; laboratory and field studies; geotextiles and geomembranes. Prerequisite: CE 143 or equivalent. Pamukcu

342. Experimental Geotechnical Engineering (3) fall
Experimental studies dealing with the measurement of soil properties in the laboratory and *in situ*; application of these properties to design; consolidation; strength of soils in triaxial compression, tensile strength, and other shear tests, including measurement of pore water pressures; model design and analysis; dynamic tests; field measurement of *in situ* soil properties; laboratory and field instrumentation. Prerequisites: CE 143 and senior standing. Pamukcu

343. Seepage and Earth Structures (3) spring
Long- and short-term stability of embankments and cut

slopes; numerical and graphical methods of stability analysis; seepage through soil; design of earth dams, embankments and excavations; influence of embankment stability; construction control, field measurement of pore pressures and earth movements; model studies. Prerequisite: CE 143 or equivalent. Fang

344. Soil Behavior (3) spring
Soil mineralogy, bondage, crystal structure and surface characteristics, soil depositional and compositional characteristics, clay-water electrolyte system, ion-exchange reactions, soil fabric, structure and property relationships, volume change, strength and deformation behavior. Prerequisite: CE 143.

345. Environmental Geotechnical Engineering (3) fall
Behavior of soil and rock and their interaction with various environmental cycles including the atmosphere, biosphere, hydrosphere, lithosphere and geomicrosphere. Soil-water environments, the geomorphic process of soil/rock, mass transport in polluted moist soils, effect of pollutants on soil behavior and foundations, clay liner, slurry wall design. Prerequisite: CE 143.

352. Structural Dynamics (3) spring
Analysis of linear structural systems to time-dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass techniques, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisites: Math 205, CE 159, and Mech 102.

359. Plastic Analysis and Design (3) spring
Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 259 or consent of the department chairperson. Driscoll

360. Bridge Engineering Project (3)
Design team approach to the preliminary design and cost analyses of highway bridges in steel, reinforced concrete, and prestressed concrete. Emphasis is on the total design concept, and includes foundations, substructure, superstructure, economy, strength, and performance. Also included are bridge inspection methods, rating evaluations, and retrofit, rehabilitation, and replacement concepts. Prerequisites: CE 261 and CE 263.

365. Prestressed Concrete (3) spring
Principles of prestressing. Analysis and design of basic flexural members. Instantaneous and time-dependent properties of materials. Prestress losses. Additional topics may include continuity, partial prestressing, compression members, circular prestressing, etc. Prerequisite: CE 263 or consent of the department chairperson. Mueller

370. Water and Wastewater Treatment (3)
Unit operations and processes in water and wastewater treatment, sedimentation, coagulation, flocculation, filtration, disinfection, chemical treatment, ion exchange, adsorption, biological oxidation, sludge dewatering and stabilization. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CE 270 or equivalent. Kugelman, Johnson

374. Environmental Chemistry (3)
Chemical principles and applications of those principles to the analysis and understanding of aqueous environmental chemistry in natural waters and wastewaters. The chemistry of ionic equilibria, redox reactions, precipitation/dissolution, acid-base concepts, buffer capacity, complexation, hydrolysis and biological reactions. Laboratory experiments. Prerequisite: Chem 31 or equivalent, or CE 270. Sengupta

375. Environmental Engineering Laboratory (3)

Application of laboratory based techniques to solution of environmental engineering problems. Chemical and microbiological analysis for key pollution parameters. Use of small pilot and bench scale equipment to generate design parameters. Illustration of techniques for scale-up using parameter values generated in laboratory. Practice in use of automated instrumentation for analysis. Prerequisite: CE 370, previously or concurrently. Sengupta, Kugelman

378. Water Resources Engineering Design (3) spring

Project-oriented design utilizing principles of hydraulics, hydrology and environmental engineering. Course will include lectures on selected water resource engineering topics and a design project. Prerequisites: CE 270 and CE 222. Weisman

381. Special Topics (1-3)

A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chairperson.

385. Research Procedures Seminar (1) fall

Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids.

Graduate Programs

Graduate studies in civil engineering enable the student to build upon the broad background of undergraduate education in preparation for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of individual program objectives that may be concentrated in one of the technical specialty areas, or, alternatively, may extend over the broad field of civil engineering. The department offers advanced work in the specialty areas of structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, and environmental engineering, leading to the degrees of master of science, master of engineering, and doctor of philosophy.

A graduate program leading to the M.S. normally is concentrated in one, or possibly two, of the technical specialty areas, and consists of a number of courses designed to fulfill the individual student's program objectives. Each candidate for the M.S. is required to submit a thesis representing three to six credit hours (CE 491, listed below), or alternatively, a report based on a research course of at least three credits (CE 481). The balance of the program will consist of courses in the specialty area(s).

A graduate program leading to the M.Eng. degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the M.Eng. is required to complete an individual engineering project representing three to six credits in place of the thesis or research report required for the M.S. (CE 480).

The doctoral program, which leads to the Ph.D., normally includes courses in the major field, courses in minor fields, and a dissertation presenting results of original research. Holders of master's degrees planning to become candidates for the Ph.D. take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, the candidate's departmental Ph.D. committee, and the department chairperson.

The laboratories of the department are located in the Fritz Engineering Laboratory. The laboratory offers outstanding facilities for research and instruction in structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, environmental engineering, and related fields. In particular, the structural testing equipment includes dynamic testing machines, a five-million-pound universal hydraulic testing machine, and

other special loading apparatus. Included in the latter are the facilities of the NSF-ERC ATLSS center located on the mountain top section of the campus. These include the largest 3-dimensional test bed in the U.S.A. and specialized earthquake testing facilities. The recently expanded hydraulic facilities include a wave tank, several flumes, a 10 cfs recirculating flow system, and two multipurpose tanks for model studies. An interdisciplinary relationship with the Environmental Studies Center facilitates the development of research programs in environmental engineering. Brochures describing the research facilities and programs are available on request.

In addition to departmental courses, a number of courses offered by the departments of mechanical engineering and mechanics, chemistry, chemical engineering, materials science and engineering, geological sciences, and biology may also be considered a part of the major field in civil engineering. A list of such courses is available through the department chairperson.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching activities required of holders of assistantships provide a valuable educational experience that supplements the formal course offerings. The graduate course offerings of the department are programmed to fit the schedule of half-time assistants, and to accommodate part-time students. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

402. Analytical Methods in Civil Engineering (2)

Analytical and numerical methods used in various fields of Civil Engineering. Treatment of typical ordinary and partial differential equations in Civil Engineering. Approximation by series. Variational methods, Rayleigh-Ritz, Galerkin, finite element. Finite differences, numerical integration. Problems and examples from the mechanics of solids, fluids, and other Civil Engineering fields. Prerequisite: Math 205 or equivalent.

407. Computer Methods in Civil Engineering I (3)

Modular software and data design, code optimization, debugging techniques, file management, software selection, spreadsheet and database management systems. Large systems of linear simultaneous algebraic equations, and eigenvalue problems; data smoothing and splines. Prerequisites: Math 205 or equivalent and working knowledge of FORTRAN-77.

408. Computer Methods in Civil Engineering II (3)

Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well- and ill-conditioned linear and nonlinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisites: CE 402 and CE 407 or equivalent, and working knowledge of Fortran 77 programming.

409. Finite Element Method in Structural Mechanics (3) spring

Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CE 417 and CE 407 or equivalent; working knowledge of Fortran. Kostem

412. Methodologies of Structural Design (2)

Probabilistic analysis of uncertainties associated with structural design. Characterization of loads including dead and live loads, wind, earthquake, and vehicular loads.

Variability of structural resistance based on strength limit states as well as serviceability. Assessment of safety and reliability. Deterministic and probabilistic methodologies of design. Prerequisite: CE 215 or permission of instructor.

417. Mechanics of Structural Members (4)

Behavior of structural members, under various loading conditions, in the elastic and inelastic range. Introduction to the theory of elasticity and structural behavior. Energy methods and their use in structural analysis. Introduction to the theory of plasticity. Concepts of stability. Basics of linear elastic fracture mechanics and fatigue. Prerequisites: CE 159 and Math 205.

418. Theory and Methods of Structural Analysis (4)

Theory and methods of linear and 2nd order structural analysis. Linear theory of structural members, stiffness and flexibility properties, linear transformations of structural analysis. Application of virtual work principles, and development of displacement (stiffness) and force (flexibility) methods of analysis in matrix form suitable for computer solution. Introduction to 2nd order theory of structural members and 2nd order equations of structural analysis, including stability analysis. Prerequisite: CE 159 or permission of instructor.

420. Surface Wave Mechanics (3)

Elements of hydrodynamics and wave boundary conditions; linear wave theory and wave characteristics; nonlinear wave theories and application; wind wave generation, analysis and prediction; long waves; design wave determination; laboratory investigation of surface waves. Prerequisite: consent of instructor. Sorensen.

424. Surface Water Hydrology (3)

Advanced analysis and methods in surface water hydrology. Linear and non-linear hydrograph methods. Kinematic wave and other hydraulic routing techniques. Advanced techniques for evaporation, infiltration, snow melt. Prerequisite: CE 325 or equivalent. Weisman

425. Hydraulics of Sediment Transport (3)

Hydrodynamic forces on particles, settling velocity. Sediment transport in open channel: tractive force theory, bed load and suspension theory, total load and wash load. Bedform mechanics, cohesive channel hydraulics. Sediment transport in closed conduits. Shore processes and coastline hydraulics. Prerequisite: CE 328 or equivalent. Weisman

427. Transport of Contaminants in Groundwater (3)

Groundwater flow, transport and dispersion of contaminants in the groundwater system, including review of selected biological and chemical reactions such as ion exchange, carbonate equilibrium. Computer-based state-of-the-art groundwater contaminant transport models will be used. Selected case studies will be analyzed. Prerequisite: CE 326 or equivalent. Lennon

428. Advanced Topics in Hydraulics (1-3)

Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CE 322 and consent of the department chairperson. May be repeated for credit.

429. Hydraulic Research (1-6)

Individual research problems with reports. May be repeated for credit.

436. Advanced Topics in Coastal Engineering (1-3)

Advanced study of selected topics in coastal engineering such as: non-linear wave theory, design of coastal structures, shore protection and stabilization, numerical solution of coastal hydrodynamics. Selection of topics will depend on particular qualifications of staff, as well as on the interests of the students. Prerequisite: CE 335. May be repeated for credit.

439. Coastal Engineering Research (1-6)

Individual research problems with reports. May be repeated for credit.

441. Soil Dynamics (3) fall

Vibration of elementary systems, wave propagation, dynamic soil properties, vibration of soils, foundation vibrations, dynamic bearing capacity, dynamic earth pressure problem and retaining wall, liquefaction of soils, earthquake problems. Prerequisite: CE 244 or consent of the department chairperson.

443. Advanced Soil Mechanics I (3) fall

The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics. Pamukcu

444. Advanced Soil Mechanics II (3) spring

Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and visco-elastic soils; lateral earth pressures, thermo-geotechnics. Prerequisite: CE 443.

445. Advanced Foundation Engineering (3) fall

Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow and deep foundations; flexible and rigid retaining structure design; dynamic effects; anchor and other special foundations; site investigations; design criteria for foundations; load and environmental factors. Prerequisite: a course in soil mechanics. Fang

447. Advanced Topics in Geotechnical Engineering (3)

Advanced studies in selected subjects related to geotechnical engineering. The general areas may include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and seepage, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chairperson. May be repeated for credit.

448. Plasticity and Limit Equilibrium in Geotechnical Engineering (3) spring

Application of plasticity in soil mechanics, new concepts and theories and the requirements for modeling of actual test performance of soils, limit yield/failure criteria, constitutive relations of stress-strain-time, concepts of critical state soil mechanics, rheological performance, application to problems of stability of slopes, bearing capacity of foundations and active/passive earth pressures. Prerequisite: CE 244, or consent of the department chairperson.

449. Geotechnical Research (1-6)

Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

451. Advanced Structural Theory (3) fall

Specialized methods of analysis: column analogy moment distribution. General treatment of deformation methods using matrix algebra. Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; nonlinear problems. Prerequisite: CE 418. Driscoll

453. Structural Members and Frames (3) fall

General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in

stability. Desirable preparation: Mech 415. Prerequisites: CE 402, CE 407, and consent of the department chairperson. Lu

454. Plate and Shell Structures (3)

Plates and slabs loaded transversely in their plane. Buckling and postbuckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational, and hyperbolic-paraboloidal shells. Emphasis on engineering methods. Design considerations. Prerequisites: CE 402, CE 407, and consent of the department chairperson. Ostapenko

455. Advanced Structural Dynamics (3)

Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and nuclear blast. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 402, CE 407, CE 352 or Mech 406, and CE 418 or equivalent. Kostem

456. Behavior and Design of Earthquake Resistant Structures (3)

Characteristics of earthquakes, effects of earthquakes on structures. Response of linear elastic structures to earthquakes. Response of inelastic structures to earthquakes. Behavior of structural components under cyclic loading. Principles of earthquake-resistant design. Aseismic design procedures and their implementation in codes. Prerequisite: CE 352 or equivalent.

457. Theory and Design of Steel Structures (3)

Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice. Fisher

459. Advanced Topics in Plastic Theory (3) fall

Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two- and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CE 359.

461. Advanced Bridge Engineering (3)

Students in CE 461 cover the same topics described under CE 360, but in more depth. In addition each student conducts an intensive study of a bridge-related topic of his or her choice. A short written technical report on the findings of this study is required. Prerequisites: CE 261 or CE 263.

462. Experimental Methods of Structural Analysis (3)

Analysis of structures using experimental techniques; use of mechanical devices in study of temperature deformations, foundation displacements, and integral action of structures; moire fringe method; theory of similitude with application to model design; structural analogies.

463. Experimental Methods of Structural Research (3)

Mechanical properties of structural materials and different procedures of evaluating these properties; experimental methods of stress analysis; statistical analysis of experimental data.

464. (Mech 416) Analysis of Plates and Shells (3)

Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins or Updike

465. Advanced Topics in Concrete Structures (3) fall

Advanced topics in reinforced concrete with or without prestress. Analysis and design for torsion. Limit design concepts. Design of slab systems: strength design method, yield line theory and strip method. Other topics may include composite members, probabilistic basis of design codes, and building and bridge design. Prerequisites: CE 263 or equivalent, or consent of department chairperson. Huang

466. Concrete Shell Structures (3)

Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CE 402, CE 407 and consent of the department chairperson. Ostapenko

467. Advanced Topics in Structural Engineering (1-3)

Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension system; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chairperson. May be repeated for credit.

468. (Mech 415) Stability of Elastic Structures (3)

Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

469. Structural Research (1-6)

Individual research with reports. May be repeated for credit.

470. Reaction Kinetics in Environmental Engineering (2)

Theory of reaction kinetics and its application to the design and operation of chemical, physico-chemical and biological reactors in water and wastewater treatment. Basic design equations for various types of reactors and migration of pollutants in the environment.

471. Water Treatment Facilities (3)

Theory and design of water treatment system components. Emphasis on coagulation, flocculation, sedimentation, filtration, and disinfection. Estimation of design parameters from laboratory experiments. Prerequisite: CE 370 or equivalent.

472. Waste Water Treatment Facilities (3)

Theory and design of water pollution control systems. Emphasis on film flow and suspended growth biological reactors for organic and nutrient removal. Sludge production, stabilization, dewatering and ultimate disposal. Prerequisite: CE 370 or equivalent.

473. Advanced Treatment Processes in Environmental Engineering (3)

Adsorption, ion exchange, reverse osmosis electrodialysis chemical oxidation and stripping in water and wastewater treatment. Kinetics, reactor theories and modeling in water and wastewater treatment systems. Prerequisite: CE 470 or equivalent.

474. Aquatic Chemistry (3)

Applying basic principles of aqueous chemistry for quantifying complex, environmental systems. Specific examples of air-water-soil interactions and consequent effects. Heterogeneous equilibria with more than one solid phase. Kinetics and thermodynamics of some important ionic and biological reactions. Prerequisite: CE 374.

475. Advanced Topics in Environmental Engineering (1-3)

Advanced concentrated study of a selected topic in environmental engineering such as non-point source pollution control, water reuse systems, new concepts in treatment technology, toxic substances control, etc. Topic is selected by the instructor and student. Courses may include specialized laboratory research, literature review, speciality conference attendance. Prerequisite: Department chairperson approval.

476. Environmental Engineering Microbiology (3)

Fundamentals of microbiology and biochemistry applied to environmental systems and water quality control. Systems ecology, energetics and kinetics of microbial growth, nutrition and toxicology, use of microorganisms for pollution monitoring and control. Pathogenicity and disease transmission, water quality using biological indices. Prerequisite: CE 370 or a suitable course in Biology.

477. Transport of Pollutants in Surface Waters (2)

Fundamental models of pollution migration in streams, estuaries and oceans. Diffusion, mass transport, dispersion, biological, physical, and chemical interactions. Effects on water quality especially oxygen nutrient and toxics levels. Prerequisites: CE 470, 471, 472.

478. Toxic and Hazardous Wastes (3)

Regulations for collection, transportation, disposal and storage of hazardous wastes. Containment systems, monitoring, types of liners, new and available technologies to eliminate or recover the hazardous components of the wastes. Prerequisite: CE 370 or CE 374.

479. Environmental Engineering Research (1-6)

Individual research problems in environmental engineering with report. May be repeated for credit.

480. Civil Engineering Project (1-6)

An intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

481. Special Problems (1-6)

An intensive study, with report, of a special field of civil engineering which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)

Study of current topics in civil engineering.

491. Thesis (1-6)**499. Dissertation (1-15)**

work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either bachelor degree. Interested students should consult with the undergraduate officer in the department of civil engineering.

freshman engineering year (see page 34)

second year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Mech 2	Elementary Engineering Mechanics (3)
Chm 31	Chemical Equilibria in Aqueous Systems (3)
EES 101	Geology for Engineers (3)
CE 15	Graphics for Civil Engineering (3)

second year, second semester (18 credit hours)

Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Mech 12	Strength of Materials (3)
EES 113	Life and Climate in the Rock Record (3)
Mech 102	Dynamics (3)
CE 112	Surveying (4)

third year, first semester (16 credit hours)

Math 205	Linear Methods (3)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
EES 122	Introduction to Plate Tectonics (3)
EES 133	Introduction to Mineralogy (3)

third year, second semester (19 credit hours)

CE 117	Numerical Methods in Civil Engineering (2)
CE 222	Hydraulic Engineering (4)
CE 270	Water Supply and Wastewater Management (4)
EES 134	Introduction to Optical Mineralogy and Crystallography (3)
EES 326	Geologic Evolution of North America (3)
	general studies elective (3)

summer

CE 100	Summer Employment (0)†
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fourth year, first semester (19 credit hours)

Mat 192	Structure and Properties of Materials (3)
CE 159	Structural Analysis I (4)
EES 135	Introduction to Lithology and Petrography (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 316	Hydrogeology (3)

fourth year, second semester (17 credit hours)

CE 160	Structural Design (4)
CE 202	Civil Engineering Planning and Engineering Economics (3)
EES 112	Geomorphology (3)
EES 307	Case Histories in Engineering Geology (3)
Eco 1	Economics (4)

summer

EES 341	Field Geology (6)
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fifth year, first semester (18 credit hours)

CE 207	Transportation Engineering (3)
CE 215	Probability and Statistics in Civil Engineering (3)
EES 301	Introduction to Geophysics (3)

Civil Engineering and Earth and Environmental Sciences

This program is designed for students interested in geological engineering, and leads to two bachelor of science degrees, in civil engineering and in earth and environmental sciences, both awarded at the end of the fifth year.

The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in earth and environmental sciences. On the other hand, if a student decides after two years to pursue only the bachelor of science in earth and environmental sciences, it is possible to complete the requirements in four years. If the decision to

EES 373	Geochemical Thermodynamics (3) or
Chm 187	Physical Chemistry (3) general study electives (6)
fifth year, second semester (17 credit hours)	
CE 203	Professional Development (2)
CE 290	Civil Engineering Design Project (3) Civil Engineering elective (3) approved elective (3)* general studies electives (6)

†Eight weeks of summer employment should precede the fourth year. Consult the Civil Engineering Department Chairperson.

*Elective that requires approval of the Civil Engineering Department Chairperson.

A total of 176 credit hours is required to earn both degrees.

Classical Studies

Professor. Charles Robert Phillips, III, Ph.D. (Brown).
Associate professor. David B. Small, Ph.D. (Cambridge), *director*.
Associate professor. Barbara Pavlock, Ph.D. (Cornell).
Assistant professor. Julie Williams, Ph.D. (Cambridge).

The study of classics examines firstly the origins and growth of Greek and Roman culture in the Mediterranean area and secondly its impact on that area (and others) until the present. This study is by nature interdisciplinary: the study of language and literature, history, philosophy and religion, archaeology, economics and science all contribute to an appreciation of Greco-Roman civilization.

Students in either major or minor programs may concentrate in various combinations of these and other disciplines as they relate to ancient civilization. The diversity of professional interest in the program should encourage the student to follow her or his special interests while simultaneously gaining an overview of classical civilization.

Courses in Ancient Greek and Latin lead to proficiency in language while introducing the student to major literary texts. The Joseph A. Maurer Classics Prize is awarded yearly, at the discretion of the program, to the senior(s) who has demonstrated outstanding achievement in Classics (Ancient Greek or Latin) and/or Classical Civilization. Courses in classical civilization require no knowledge of the ancient languages; they offer introductions to various disciplines of classics with frequent reference to modern perspectives. Upper-level courses tend to be small, fostering closeness between faculty and students.

Petitions are required for freshmen to take 100-level or higher courses and for sophomores to take 200-level or higher courses.

Major programs. Students may major either in Classical Civilization or Classics. The Classics major offers a comprehensive view of language and culture; it is possible to begin an ancient language at Lehigh and to complete the major program successfully. Depending on interests and preparation, the student should derive equal educational benefit from either major program. The department welcomes double majors and the educational perspectives to be derived from combining ancient and modern studies.

Classics as a major has stood the test of time, offering helpful preparation for careers in widely diverse fields in the professions, business, and public service. Lehigh classics majors have gone on to law school, the ministry, business school, with appropriate science courses to medical school, graduate work in classics, and to all kinds of entry-level employment.

Departmental Honors. A student may be recommended for Program Honors by vote of the program based on the student's course work.

Minor program. The minor in Classical Civilization or Classics consists of a minimum of fifteen credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The department can arrange individual programs.

Study abroad. Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome and of the American School of Classical Studies at Athens. Lehigh students are eligible for tuition grants at Athens and Rome.

Major in Classical Civilization

This major allows the student to concentrate either in classical archaeology or classical literature while gaining an overview of Greco-Roman culture. Each concentration is based upon 24 credit hours. Clss 21 (Hist 21) and Clss 22 (Hist 22) are an additional requirement, which brings the major up to 30 credit hours.

Concentration in Archaeology (24)

Clss 112 (Anth 112)	Doing Archaeology (3)
Clss 174 (Anth 174, Art 174, Arch 174)	Greek Archaeology (3)
Clss 176 (Anth 176, Art 176, Arch 176)	Roman Archaeology (3)
Clss 345 (Anth 345)	Evolution of the State (3)
Anth 11	Sociocultural Anthropology (3) or
Anth 12	Emergence of Mankind and Culture (3)

Three courses chosen from any of the remaining classics course offerings.

The student taking this concentration must demonstrate linguistic competence by passing either a Latin or Greek course on the intermediate or advanced level.

The program is connected with several excavation and survey projects in the Mediterranean, which the student is strongly encouraged to attend. Some financial support is available. The program additionally directs a local ethnoarchaeological project, in which students in Clss 112 participate.

Concentration in Literature (24)

Three out of the following classes in literature (9)

Clss 52 (Engl 52)	Classical Epic (3)
Clss 54 (Engl 54)	Greek Tragedy (3)
Clss 56 (Engl 56)	Ancient Novel (3)
Clss 58 (Engl 58)	Greek and Roman Comedy (3)

one course in either Latin or Greek on the intermediate or advanced level (3)

four courses taken from either the offerings of the Classics program or Phil 131, RS 111, 114, 140 (12)
relevant courses from Modern Foreign Languages or English intermediate or advanced level may be substituted for Classical Literature in translation courses.

Major in Classics

This major allows the student to concentrate in Ancient Greek, Latin or both. Specific programs for this major are worked out for each student with due consideration for the individual's particular previous study of the language(s). Students wishing to concentrate in both languages should consult the program director as soon as possible on their arrival at Lehigh. Thus a student may begin Ancient Greek or Latin at Lehigh and successfully complete a major in it.

required preliminary courses (18 credit hours maximum, depending on previous language study)

Greek 1, 2, 11, 12, or

Latin 1, 2, 11, 12 or appropriate placement as determined by program

Clss 21	Greek History (3)
Clss 22	Roman History (3)

required major courses (30 credit hours)

twelve credit hours in advanced courses in the major language

six credit hours in the second language, taken at any level

three credit hours in archaeology

three credit hours in philosophy/religion, chosen from the following: Clss 251, Phil 131, RS 111, 114

six credit hours from either classical civilization courses or approved collateral courses.

Courses in Classical Civilization (Clss)**Clss 5. Mythology (3) fall**

Introductory study of the myth-making process, both ancient and modern; emphasis on Greek myth.

Clss 21. (Hist 21) Greek History (3) fall

The development of civilization from palaeolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world; the origin of political institutions. Phillips

Clss 22. (Hist 22) Roman History (3) spring

Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips

Clss 52. (Engl 52) Classical Epic (3)

Study of major epic poems from Greece and Rome. Works include Homer's *Iliad* and *Odyssey*, Apollonius' *Argonautica*, Vergil's *Aeneid*, and Ovid's *Metamorphoses*. Pavlock.

Clss 54. (Engl 54) Greek Tragedy (3)

Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock

Clss 56. (Engl 56) The Ancient Novel (3)

Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock

Clss 58. (Engl 58) Greek and Roman Comedy (3)

Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock

Clss 74. (Anth 74) Cultures of the Greeks and Romans (3)

Analysis of Greek and roman cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature and warfare. Small

Clss 108. Ancient Technology (3) spring

Technology and technique from the stone ages to the beginning of the industrial age; their effects on society. Attitudes to technology in ancient myth literature, philosophy, and religion.

Clss 112. (Anth 112) Doing Archaeology (3)

Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small

Clss 121. (Anth 121) Environment and Culture (3)

Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/environmental interaction. Small

Clss 127. (Anth 127) Early Civilizations (3)

Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and the New World. Similarities and differences in economics, politics, social organization, and religion. Small

Clss 131. (Phil 131) Ancient Philosophy (3) fall

Historical study of philosophy in the classical world from the pre-Socratics to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political, and scientific life of their times.

Clss 132. Medical Terminology (1-3)

Basic knowledge of Greek and Latin roots used in medical and health sciences. Rules for combining forms, for recognition of variants. Exercises in etymology.

Clss 152. Women in Antiquity (3)

Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material.

Clss 161. Roman Law (3)

Examination of Roman legal systems from the *Twelve Tables* to the *Digest* of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips

Clss 174. (Anth 174, Art 174, Arch 174) Greek Archaeology (3)

Ancient Greek culture from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small

Clss 176. (Anth 176, Art 176, Arch 176) Roman Archaeology (3)

Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from the study of artifacts. Small

Clss 178. (Anth 178) Mesoamerican Archaeology (3)

Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructions of urban centers, political and economic organizations, and theories of Mayan collapse. Small

Clss 201. (Art 201) Archaeology: Lands of the Bible (3)

Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and late cultures in the Near East. Material illustrating the cultures and events of the Bible.

Clss 204. (Arch 204) Ancient City and Society (3)

Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, Rome, and New World; insights applicable to current urban problems. Small

Clss 213. (Rel 213) Ancient Roman Religion (3)

Religious experience of the Roman people from prehistory to end of the Empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials. Phillips

Clss 215. (Hist 215) Decline and Fall of the Roman Empire (3)

Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips

Clss 220. (Hist 220) Golden Age of Greek Democracy (3)

Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers.

Clss 251. (Rel 251) Classical Mythology (3)

Myth, religion, and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of religion. Cross-cultural material.

Clss 281. Readings (3) fall
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Clss 21 or 22 and consent of the department chairperson.

Clss 282. Readings (3) spring
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Clss 21 or 22 and consent of the department chairperson.

Clss 345. (Anth 345) Evolution of the State (3)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and the New World. Small

Courses in Ancient Greek

Grk 1. Elementary Ancient Greek (3) fall
Fundamentals of the Greek language. Readings in the easier authors. Staff

Grk 2. Elementary Ancient Greek (3) spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: Grk 1. Staff

Grk 11. Intermediate Ancient Greek (3) fall
Readings in Herodotus, Homer, or Xenophon. Grammar review. Prerequisite: Grk 1 and 2, or one year of entrance Greek, or consent of department chairperson.

Grk 12. Intermediate Ancient Greek (3) spring
Plato: *Euthyphro*, *Apology* and *Crito*, or other dialogues. Prerequisite: Grk 11.

Grk 111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Grk 12.

Grk 112. Greek Drama (3) spring, alternate years
Continuation of Gk 111. Prerequisite: Grk 12.

Grk 113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: Grk 12.

Grk 271. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours at the 100 level and consent of the department chairperson.

Grk 272. Readings (3) spring
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours of courses at the 100 level and consent of the department chairperson.

Courses in Latin

Lat 1. Elementary Latin (4) fall
Fundamentals of grammar and syntax. Introduction to Ovid's version of Greek mythology. Emphasis on language structure and vocabulary building.

Lat 2. Elementary Latin (3) spring
Easy Latin prose and poetry. Prerequisite: Lat 1 or one to two years of entrance Latin.

Lat 11. Intermediate Latin (3) fall
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 12. Intermediate Latin (3) spring
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 111. Catullus and Horace (3)
Translation and analysis of selected lyrics, focusing on

imagery systems. Introduction to metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 112. Republican Prose: The Roman Revolution (3)
Letters of Cicero; Sallust's *Catiline*. Prerequisite: Lat 12 or consent of chairperson.

Lat 113. Vergil (3)
Selections from the *Aeneid*. Vergil's creation of a Latin epic and its ambiguities. Metrics. Prerequisite: Lat 12 or consent of chairperson.

Lat 114. Livy (3)
Selections from the early books of Livy's histories focusing on his creation of a Roman *mythos*. Style. Prerequisite: Lat 12 or consent of chairperson.

Lat 115. Ovid (3)
Selections from the *Ars Amatoria* and *Metamorphoses* 6-10, focusing on Ovid's problem with ideology. Metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 116. Petronius (3)
Selections from the *Satyricon*, focusing on language usage and epic travesty. Prerequisite: Lat 12 or consent of chairperson.

Lat 211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 303. The Roman Epic (3)
The epic in Latin literature; selections from Lucretius, Catullus and Ovid; critical study of Vergil's *Aeneid*. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Cognitive Science

Mark H. Bickhard, Ph.D. (U. of Chicago), *director, Cognitive Science Program; 758-3633; MHB@uic.edu*

Cognitive science is the interdisciplinary study of the relationship between how humans think and how machines think: How can our understanding of the way humans think improve the performance of machines that are meant to behave intelligently? How can our understanding of the ways to make machines behave intelligently improve our understanding of the way humans think? The disciplines most commonly involved in cognitive science studies are anthropology, psychology, computer science, linguistics, and philosophy.

The College of Arts and Sciences offers a major in Cognitive Science, as well as a minor. Because of its broad interdisciplinary character, a cognitive science major prepares a student for a wide variety of careers or graduate study programs. The courses required for the major also readily lend themselves to a double major for those students in the humanities, natural sciences, or computing science who have overlapping interests in cognitive science.

The B.A. with a major in Cognitive Science requires a minimum of 43 credit-hours: 36 within the major itself and at least 7 in collateral areas. All majors are required to take Cognitive Science 7 an introduction to cognitive science. The remainder of the major is built around a core of four introductory courses, one from each of four disciplines central to cognitive science: cognitive psychology, artificial intelligence, philosophy, and linguistics. In addition, majors must complete six elective courses, two in each of three

topical areas related to cognitive science. The final integration of coursework occurs in the required senior seminar, in which students focus on a topic of their choice from a branch of cognitive science.

The collateral course requirements include Math 9 Introduction to Finite Mathematics (3, Fall), CSc 11 Introduction to Structured Programming (3) and CSc 15 Data Structures (3) or CSc 17 Structured Programming and Data Structures (4). Students who take CSc 261 to satisfy the major electives requirement should take Math 21 (a prerequisite of CSc 261) in place of Math 9. Additional coursework in mathematics is strongly recommended, as are: Psychology 1 or 11, Biology 31 and 32, and Anthropology 12.

Required Introductory Course

CogS 7 Introduction to Cognitive Science (3) spring

Collateral Requirements (7-9 hours)

Math 9 Introduction to Finite Mathematics (3)
CSc 11 Introduction to Structured Programming (3) **and**
CSc 15 Data Structures (4) **or**
CSc 17 Structured Programming and Data Structures (4)

Disciplinary Core Courses (12 hours)

CSc 327 Artificial Intelligence Applications (3)
Phil 250 The Minds of Men and Robots (3)
Psyc 117 Cognitive Psychology (3)
CogS 140 (Mfl 140; Psyc 140; Anth 140) Introduction to Linguistics (3)

Major Electives (18 hours)

After completing the introductory sequence and the four core courses, students must complete two courses from any three of the following groups.

Artificial Intelligence and Expert Systems:
CSc 262 Programming Languages (3)
CSc 365 Natural Language Understanding (3, prereq: CSc 262)
CSc 368 Artificial Intelligence (3, prereq: CSc 262)

Students who qualify may take
CSc 413 Robotics and Intelligence Machines (3), **or**
CSc 463 Computational Linguistics (3)

Formal Models:
Phil 114 Fundamentals of Logic (3)
Phil 214 Logical Theory (3)
CSc 261 Discrete Structures (3, prereq: Math 21 and either CSc 11 or Eng 1)
CSc 318 Automata and Formal Grammars (3, prereq: CSc 261)

Philosophy:
Phil 139 Contemporary Philosophy (3)
Phil 220 Knowledge and Justification (3)
Phil 251 Action, Free Will, and Fate (3)

Cognitive Psychology:
Psyc 307 Seminar in Cognition (3, prereq: Psyc 117)
Psyc 320 Psycholinguistics (3)

Psyc 351 Cognitive Development in Childhood (3, prereq: Psyc 107 or Psyc 117)

Sociocultural Influences on Cognition:
SSP 135 Human Communication (3)
SSP 307 Attitudes, Attributions, and Actions (3)
Anth 376 Mind, Self and Culture (3)

Neuroscience:
Psyc 176 Introduction to Cognitive Neuroscience (3)
Psyc 177 Introduction to Physiological Psychology (3)
Psyc 373 Sensation and perception (3, prereq: Psyc 176)
Psyc 375 Neuroanatomy of Behavior (3, prereq: Psyc 177)

Senior Seminar (3 hours)

After completing the sophomore introductory sequence and the four major courses, students pursue their own interests in their selections of major electives. The required senior seminar brings classmates together so that they can teach each other what they have learned in their respective concentrations. This integrates the material in the program and provides students the opportunity to undertake independent projects.

Recommended Timing of Courses

Freshman	Sophomore
CogS 7 (spring)	2 Core Courses CSc 11 & 15 or CSc 17 Math 9
Junior	Senior
2 Core Courses Major electives	Major electives CogS 301 (spring)

Minor In Cognitive Science

The minor in Cognitive Science requires the following courses:

CogS 7 Introduction to Cognitive Science
Math 9 Introduction to Finite Mathematics or CSc 261 Discrete Structures
CSc 327 Artificial Intelligence Applications
Phil 250 The Minds of Men and Robots
Psyc 117 Cognitive Psychology
CogS 140 Introduction to Linguistics

Course Descriptions

7. Introduction to Cognitive Science (3) spring

What is a mind? How is the mind related to the brain? Could we make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

140. (Mfl 140; Psych 140; Anth 140) Introduction to Linguistics (3)

Relationship between language and mind; formal properties of language; language and society; how languages change over time.

301. Senior Seminar in Cognitive Science (3) spring

Integration of the material from cognitive science on topics chosen by the students.

478. (Psyc 478) Ontological Psychology (3).

Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.

Roy Eckardt College Scholar Program

Director. Ian Duffy, *professor of history.*

Advisory Committee. Mark Bickhard, *professor of psychology;* Bobb Carson, *professor of earth and environmental sciences;* Beall Fowler, *professor of physics;* Edward Gallagher, *professor of English;* Lucy Gans, *professor of art and architecture;* Norman Girardot, *professor of religion studies;* Charles Kraihanzel, *professor of chemistry;* Norman Melchert, *professor of philosophy;* Julie Williams, *associate dean.*

For program requirements, see page 30.

389. Honors Project for College Scholars (1-6)

Opportunity for College Scholars to pursue an extended project for senior honors. May be repeated for credit. Transcript will identify department in which project was completed. Prerequisite: consent of department chairperson.

C.S. 281. College Scholar Seminar (3)

Seminars for College Scholars. Prerequisite: consent of program director.

Communication

See listings under Minor Programs in the College and under Journalism and Communication.

Computer Engineering

See listings under Electrical Engineering and Computer Science.

Computer Science

See listings under Electrical Engineering and Computer Science.

Cooperative Undergraduate Education

Certain departments offer limited opportunities to students for cooperative work assignments with industrial or business firms and government agencies. In all cases cooperative work assignments are optional on the part of the student and there is no obligation for the student to accept permanent employment nor for the cooperating organization to offer permanent employment.

When on a cooperative assignment, the student must register for the non-credit course, Cooperative Undergraduate Education, to maintain continuous student status. The fee for this course is established by the University Treasurer. Participation in a cooperative education program does not relieve the student from any regular requirement for the academic curriculum in which he or she is enrolled.

Details of cooperative arrangements vary with different curricula. Each department offering cooperative education will provide the details of its program in writing to interested students.

200. Cooperative Undergraduate Education (0)

Supervised cooperative work assignment to obtain practical experience. Prerequisite: consent of the department chairperson.

Counseling

See listings under Education.

Earth and Environmental Sciences

Professors. Bobb Carson, Ph.D. (Washington); Edward B. Evenson, Ph.D. (Michigan); Kenneth P. Kodama, Ph.D. (Stanford), *chairperson*; Paul B. Myers, Jr., Ph.D. (Lehigh); Dale R. Simpson, Ph.D. (Cal. Tech.); Craig E. Williamson, Ph.D. (Dartmouth).

Associate professors. David J. Anastasio, Ph.D. (Johns Hopkins); Bruce R. Hargreaves, Ph.D. (California); Carl O. Moses, Ph.D. (Virginia); Hayden N. Pritchard, Ph.D. (Lehigh); Peter K. Zeitler, Ph.D. (Dartmouth).

Assistant professors. Gray E. Bebout, Ph.D. (California); Anne S. Meltzer, Ph.D. (Rice); Donald P. Morris, Ph.D. (Colorado).

Visiting assistant professor. Eugene S. Ilton, Ph.D. (Johns Hopkins).

The Department of Earth and Environmental Sciences offers undergraduate and graduate degree programs in Geological Sciences and Environmental Sciences. An undergraduate degree program in Geophysics is also available. Faculty in the department have specialized expertise in diverse fields and can offer students the broadly based education that will be required to work or conduct research in the earth and environmental sciences. Below, our undergraduate and graduate major and minor programs are discussed in more detail.

Environmental Science

Environmental systems, consisting of air, water, solid Earth materials, and life, have existed, interacted, and coevolved for billions of years. Humans are relative newcomers to Earth's surficial environment, but the intensity of our interaction with the environment far exceeds that of other species. Environmental science is an emerging field of study that draws on all of the traditional scientific disciplines and adds to them its specific purpose: to understand environmental systems and the processes through which they interact. The primary task of environmental scientists is to develop a conceptual framework for studying and understanding the environment.

The environmental science curricula offered by Lehigh are intended to help students focus their curiosity about the environment on the study of current human understanding of environmental systems and to engage students in the ongoing processes of developing the framework for understanding the environment and making new discoveries that advance that understanding. Lehigh offers two undergraduate majors in environmental science, one leading to a bachelor of science degree and one leading to a bachelor of arts degree. Our degree programs are designed to ensure a firm foundation in mathematics, communication skills, and the traditional sciences (chemistry, physics, geology, and biology), to provide a breadth of understanding of environmental systems, and to develop a depth of competence in the individual student's chosen area of specialization. Ultimately as one becomes an environmental scientist, one's educational experience must include direct interaction with the environment, and our degree programs require a component of experiential learning. This requirement can be satisfied through field courses, research participation, or internships, for example.

Participation in research is especially encouraged, and course credit for research projects can be easily arranged. During the spring semester of the senior year, all environmental science students participate in a seminar that integrates the entire curriculum through discussion of current issues on the forefront of environmental science. Students considering a major in either curriculum are urged to contact either Professor Williamson or Professor Moses the undergraduate advisor for environmental science advisors in the department.

A minor in environmental science is available for students who wish to combine an interest in environmental science with technical or non-technical majors, such as engineering, economics, government, journalism, international relations, and others.

A degree in environmental science prepares a student for graduate study in environmental science, other fields of science or engineering, education, law, medicine, business or other areas, depending on one's interests and choice of electives. Employment opportunities exist in a number of fields, including consulting firms, manufacturing companies, natural resource corporations, financial institutions, government agencies, schools, and lobbying and advocacy groups.

Major requirements for a B.S. in Environmental Science

A total of 121-125 credit hours are required.

college and university requirements (28 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8, or 10	Composition and Literature (3)
Arts & Science 1	Choices and Decisions (1)
FS 90	College Seminar (1st yr.) (3)
	Electives (9 cr. humanities, 9 cr. social science) (18)

collateral sciences (32 credit hours)

Chm 21, 22	Introductory Chemistry and Laboratory (5)
Chm 31	Chemical Equilibria in Aqu. Systems (3)
Chm 51	Organic Chemistry I (3)
Math 21, 22, 23	Calculus I, II, III (12)
Phy 11, 12, 13, 14	Intro and general physics and lab (9)

major program (48-56 credit hours)

Introductory Sequence of Courses (8-10 credit hours)

EES 21	Introduction to Earth Materials and Processes (4) or
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6) and
EES 31, 32	Intro to Environmental and Organic Biology and Lab (4)

Introductory core course

EES 181	Introduction to Earth and Life Systems (4)
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Breadth and skills requirement (15-17 credit hours)

Choice of two earth systems courses (6)

Earth Systems

EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution (3)
EES 122	Introduction to Plate Tectonics (3)
EES 131	Introduction to Rocks and Minerals (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 231	Mineralogy and Crystallography (3)

Choice of two life systems courses (6-8)

Life Systems

MBio 31, 32	Introduction to Cell and Molecular Biol and lab (4)
MBio 101, 102	Genetics and lab (4)
EES 162	Non Vascular Plants (3)
EES 163	Evolution of Vascular Plants (3)
BEB 134	Comparative Vertebrate Anatomy (3)
EES 251, 252	Ecology and lab (4)

Statistics: Math 231 or EES 382 (3)

specialization requirement (12-16 credit hours)

Choice of four courses at the 300 level, three of which are EES courses. The student must submit to the adviser to the ES major (Williamson/Moses) a written justification of how the four courses selected serve to increase the student's depth of competence in some area. This written statement must be filed no later than the time of preregistration for the first semester of the senior year.

approved professional electives (6 credit hours)

At least two courses chosen to support the professional objectives of the student, subject to approval by the adviser to the ES major (Williamson/Moses). Professional electives must be at the 200 level or above in the department and at the 100 level or above in other departments.

advanced core seminar (3 credit hours)

EES 381	Senior Seminar in Environmental Sciences (3)
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free electives (6-12 credit hours)

Courses chosen from anywhere in the University's curriculum to bring total credits of program to 121. Minimum of 4 credits.

Additional Requirements

Laboratory requirement. At least six laboratory courses, at least two of which are at the 200 level or above.

Field experience requirement. Approved field experience: ie. EES 41; EES 341; or approval by the adviser to the ES major (Williamson/Moses) for the equivalent of three credit hours of field experience in the form of a field course at another institution, a field research project, or a work experience.

Recommended Sequence of Courses

Fall	Spring
freshman year, fall	
Engl 1 (3)	Engl 2 (3)
EES 21 (4)	EES 31, 32 (4)
Math 21 (4)	Math 22 (4)
College Seminar (3)	Chm 21, 22 (5)
A & S I (1)	
sophomore year	
Math 23 (4)	EES 181 (4)
College Elec. (3)	Phys 13, 14 (5)
Chm 31 (3)	B & S Earth Sys. (3)
Phy 11, 12 (5)	B & S Life Sys. (3-4)
junior year	
College Elec. (3)	College Elec. (3)
Chm 51 (3)	Spec. Req. 3xx (3-4)
B & S Earth Sys. (3)	Spec. Req. 3xx (3-4)
B & S Life Sys. (3-4)	Prof. Elec. (3)
EES 382 (3)	Prof. Elec. (3)
or Math 231 (3)	

Summer
Summer field experience (3-6 credits)*

senior year

College Elec. (3)	College Elec. (3)
Spec. Req. 3xx (3-1)	EES 381 (3)
Spec. Req. 3xx (3-1)	College Elec. (3)
College Elec. (3)	College Elec. (3)
	Free Elec. (3)

*See major program listing for alternatives

B.A. in Environmental Science

A total of 121-126 credit hours is required.

college and university requirements (28 credit hours)

	English Composition (6)
	Arts and Science I (1)
	College Seminar (1st yr.) (3)
Electives	(min. 9 cr. social sciences) and (min. 9 cr. humanities) (18)

collateral sciences (16-18 credit hours)

Chm 21, 22	Introductory Chemistry and laboratory (5)
Math 41, 44	Calculus I, II (3-4) or
Math 21, 22	Analytic Geometry and Calculus I, II (3-4)
Phy 11, 12	Intro Physics and laboratory (5)

Major program (51-62 credit hours)**Introductory Sequence of Courses (8-10 credit hours)**

EES 21	Introduction to Earth Materials and Processes (4) or
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6)
EES 31, 32	Intro to Environmental/Organismal Biology and laboratory (4)

Introductory core course

EES 181	Intro to Earth and Life Systems and laboratory (4)
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Breadth and skills requirement (15-17 credit hours)

Choice of two earth systems courses (6)

Earth Systems

EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution (3)
EES 122	Introduction to Plate Tectonics (3)
EES 131	Introduction to Rocks & Minerals (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 231	Mineralogy and Crystallography (3)

Choice of two life systems courses (6-8)

Life Systems

MBio 31, 32	Introduction to Cell and Molecular Biol and lab (4)
MBio 101, 102	Genetics and lab (4)
EES 162	Non Vascular Plants (3)
EES 163	Evolution of Vascular Plants (3)
BEB 134	Comparative Vertebrate Anatomy (3)
EES 251, 252	Ecology and lab (4)

Statistics:

Math 12	Statistical Methods (3) or
Math 231	Probability and Statistics (3) or
EES 382	Statistical Applications (3)

specialization requirement (9-12 credit hours)

Choice of at least three courses at the 300 level, two of which are EES courses. The student must submit to the adviser of the ES major a written justification of how the three courses selected serve to increase the student's depth of competence in some area. This written statement must be filed no later than the time of preregistration for the first semester of the senior year.

Electives in the major (12-16 credit hours)

At least four courses at the 100-level or above in the department or related courses in math, science, or engineering.

free electives (minimum of 18 credit hours)

Courses chosen from anywhere in the University's curriculum, including courses in EES, to bring total credits in the major to 121.

advanced core seminar (3 credit hours)

EES 381	Senior Seminar in Environmental Sciences (3)
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Additional requirements for graduation, B.A.

Laboratory requirement. At least six laboratory courses, at least two of which are at the 200 level or above.

Field experience requirement. Approved field experience: ie. EES 41; EES 341; or approval by the adviser to the ES major for the equivalent of three credit hours of field experience in the form of a field course at another institution, a field research project, or a work experience.

Recommended Sequence of Courses

Fall	Spring
freshman year, fall	
Engl 1 (3)	Engl 2 (3)
A & S I (1)	Math 44 or 22 (3-4)
College Sem. (3)	Phy 11, 12 (5)
Human. Dist. (3)	EES 31, 32 (4)
Math 41 or Math 21 (3-4)	
Soc. Sci. Dist. (3)	
sophomore year	
EES 21 (4)	Soc. Sci. Dist. (3)
Soc. Sci. Dist. (3)	Human. Dist. (3)
Chm 21, 22 (5)	Free Elec. (3)
	Free Elec. (3)
junior year	
EES 382 or Math 12 (3)	B & S Earth Sys (3)
or Math 231	B & S Life Sys (3-4)
B & S Earth Sys (3)	Spec. Req. 3xx (3-4)
B & S Life Sys (3-4)	Elec. in the Maj. (3-4)
Spec. Req. 3xx (3-4)	Elec. in the Maj. (3-4)
Elec. in the Maj. (3-4)	

Summer

Summer field experience (3-6 credits)*

senior year

Spec. Req. 3xx (3-4)	EES 381 (3)
Elec. in the Maj. (3-4)	Free Elec. (3)
Free Elec. (3)	Free Elec. (3)
Free Elec. (3)	Free Elec. (3)

*See major program listing for alternatives

Environmental Science Minor

(18-21 credit hours)

Introductory sequence (8-10 credit hours)

EES 21	Introduction to Earth Materials and Processes (4) or
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6)
EES 31, 32	Intro to Environmental and Organic Biology and laboratory (4)

Introductory core course

EES 181	Introduction to Earth and Life Systems (4)
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Breadth and skills requirement (6-7 credit hours)

Choice of one earth systems course (3)

Earth Systems

EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution (3)
EES 122	Introduction to Plate Tectonics (3)
EES 131	Introduction to Rocks & Minerals (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 231	Mineralogy and Crystallography (3)

Choice of one life systems course (3-4 credit hours)

Life Systems

MBio 31, 32	Introduction to Cell and Molecular Biol and lab (4)
MBio 101, 102	Genetics and lab (4)
EES 162	Non Vascular Plants (3)
EES 163	Evolution of Vascular Plants (3)
BEB 134	Comparative Vertebrate Anatomy (3)
EES 251, 252	Ecology and lab (4)

Geological Sciences

Geology, geophysics, and geochemistry deal with natural phenomena on or within the earth. Each makes use of other more fundamental sciences in its practice; hence, the student preparing for a career in one of the geological sciences combines study in earth science with a broad understanding of physical, chemical, and biological principles.

Lehigh offers two undergraduate majors in geological sciences, one leading to the degree of bachelor of science, the other to the degree of bachelor of arts. The bachelor of science curriculum is designed to permit a concentration in depth in the major whereas the bachelor of arts curriculum provides the opportunity for a broad liberal-arts education centered around geoscience. If the electives in the bachelor of arts program are selected carefully, the B.A. program provides the opportunity for (1) a minor in an area of the humanities and social sciences; and (2) entry into graduate-level studies in fields such as geology, environmental science, marine science, environmental law, etc. Students contemplating a major in either curriculum are strongly urged to discuss the selection of electives, collateral sciences, career goals, and job opportunities with professors Anastasio, Myers, or Zeitler, the undergraduate advisers in the department.

The bachelor of arts program requires fewer credits for graduation (121-124 vs. 126 credit hours), and fewer courses in collateral sciences and mathematics (20-22 vs. 33 credit hours). Candidates for the bachelor of science degree are required to take fifteen credit hours in approved professional electives. The professional electives permit the student to arrange for an informal concentration in geochemistry, geophysics, hydrogeology, etc. Major electives in the B.A. curriculum provide a similar opportunity for concentration, but comprise 12, rather than 15 credit hours.

Students electing the bachelor of arts program are required to meet the distribution requirements of the College of Arts and Science; candidates for the bachelor of science degree take eighteen credit hours of nonprofessional electives in place of the distribution requirements.

All geological sciences majors are strongly encouraged to undertake an undergraduate research project during their senior year. Normally, students register for 3-6 credit hours of geological research (EES 291), and work on a field/laboratory problem in close cooperation with an individual faculty member. Students contemplating a research project should discuss potential areas of research with appropriate faculty at least one semester before registering for geological research, preferably in their junior year.

Both the bachelor of science program and the bachelor of arts program provide preparation for graduate school. Qualified students may be given permission at the end of the

junior year to enter a program wherein they are able to begin work toward a graduate degree during the senior year. (See Combined B.A. or B.S. and M.S. program below.)

A minor in geological sciences is available for students who wish to combine an interest in earth science with technical or non-technical majors such as engineering, chemistry, mathematics, economics, management, government, international relations, English, journalism, and others.

Geological training is utilized in a variety of industries (especially in petroleum, mining, construction engineering, ceramics, and metallurgical industries), state and federal government service, natural resources management, and secondary school, college, and university teaching.

At the present time, career opportunities are particularly strong in the ground water industry, for work in contaminant mitigation, procurement of ground water supplies, and in ground water management.

A major in geophysics is offered in conjunction with faculty from cooperating departments. This program is described under "Geophysics".

Major Requirements for B.S. in Geological Sciences

A total of 122-126 credit hours is required.

college and university requirements (28 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6,	Composition and Literature or
8, or 10	Composition and Film Study (3)
Arts & Science 1	Choices and Decisions
FS 90	College Seminar (3)
Dist. Elec.	(18 hours; 9 hrs. humanities, 9 hrs. social sciences)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a minimum of 12 credit hours in humanities courses, and a minimum of 12 credit hours in social sciences courses, as defined by the faculty for the bachelor of arts curriculum.

major program (91-92 credit hours)**mathematics (12 credit hours)**

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry & Calculus II (4)
Math 23	Analytic Geometry & Calculus III (4)

collateral sciences (21 credit hours)

Chm 21, 22	Introductory Chemistry Principles and Laboratory (5)
Chm 31	Chemical Equilibria in Aqueous Systems (3)
Phy 11, 12	Introductory Physics I and Laboratory (5)
Phy 21, 22	Introductory Physics II and Laboratory (5)
CSC 11	Introduction to Structured Programming (3)

geological sciences (58-59 credit hours)

EES 21	Introduction of Earth Materials and Processes (4) or
EES 101	Geology for Engineers (3) or
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6)
EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution: Life and Climate (3)
EES 122	Introduction to Plate Tectonics (3)
EES 131	Introduction to Rocks & Minerals (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)

EES 231	Mineralogy and Crystallography (3)
EES 292	Research Seminar (1)
EES 301	Introduction to Geophysics (3)
EES 326	Geologic Evolution of North America (3)
EES 334	Igneous & Metamorphic Petrology (3)
EES 341	Field Geology (6)
EES 373	Geochemical Thermodynamics (3)

Note: EES 41 may be substituted for EES 21, or EES 11, or EES 101, and EES 112. Before taking EES 341, it is recommended that a student complete EES 21, 112, 113, 131, 213, and 223.

approved major electives (15 credit hours)

Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. At least one professional elective, approved by the undergraduate advisors, must be a science, math or engineering course, taken outside of the Department of Earth and Environmental Sciences. Examples of coherent groups of courses that may serve to fulfill this requirement are as follows:

free electives (6 credit hours)

Courses chosen from anywhere in the University's curriculum to bring total credits of program to 121. Minimum of 3 credit hours.

Emphasis on Mineralogy-Petrology-Economic Geology

EES 336	Mineral Phase Relations (3)
EES 337	X-ray Diffraction of Materials (3)
EES 338	Electron Microscopy and Microanalysis (4)
EES 331	Economic Geology (3)
EES 374	Isotope Geochemistry and Geochronology (3)

Emphasis on Surficial and Sedimentary Geology

EES 309	Environmental Magnetism (3)
EES 414	Glacial and Quaternary Geology (3)
EES 315	Soil Genesis (3)
EES 326	Evolution of North America (3)
EES 313	Depositional Environments and Facies Analysis (3)
EES 382	Statistical Applications (3)
EES 375	Water-Rock Interaction Seminar (1)
EES 376	Geochemistry of Natural Waters (3)
CE 143	Soil Mechanics

Emphasis on Tectonics

EES 302	Solid Earth Geophysics
EES 306	Geophysical Field Techniques (3)
EES 308	Seismic Data Analysis (3)
EES 313	Depositional Environments and Facies Analysis (3)
EES 324	Structural Analysis (3)
EES 326	Geologic Evolution of North America (3)
EES 374	Isotope Geochemistry and Geochronology (3)
Math 205	Linear Methods (3)

Emphasis on Hydrogeology

EES 306	Geophysical Field Techniques (3)
EES 315	Soil Genesis (3)
EES 316	Hydrogeology (3)
EES 319	Evaluation and Management of Ground-Water Resources (3)
EES 313	Depositional Environments and Facies Analysis (3)
EES 382	Statistical Applications (3)
EES 375	Water-Rock Interaction Seminar (1)
EES 376	Geochemistry of Natural Waters (3)
CE 381	Special Topics (1-3)

Other coherent groups of courses that meet the specific objectives of the individual student may be selected with the

approval of an undergraduate faculty advisor (professor Anastasio, Myers, or Zeitler).

Recommended Sequence of Science Courses

freshman year

EES 21	Introduction to Earth Materials and Processes (4) or
EES 101	Geology for Engineers (3) or
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6) (summer preceding or following freshman year)
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chm 21, 22	Introductory Chemical Principles and Laboratory (5)
Phy 11, 12	Introductory Physics I and Laboratory (5)

sophomore year

EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
EES 122	Introduction to Plate Tectonics (3)
EES 131	Introduction to Rocks & Minerals (3)
EES 231	Mineralogy and Crystallography (3)
Math 23	Analytic Geometry & Calculus III (4)
Phy 21, 22	Introductory Physics II and Laboratory (5)
Chm 31	Chemical Equilibria in Aqueous Systems (3)

junior year

CSc 11	Introduction to Structured Programming (3)
EES 135	Introduction to Lithology and Petrography (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 231	Mineralogy and Crystallography (3)
EES 292	Research Seminar (1)
EES 373	Geochemical Thermodynamics (3)

summer following junior year

EES 341	Field Geology (6)
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senior year

EES 301	Introduction to Geophysics (3)
EES 326	Geologic Evolution of North America (3)
EES 334	three professional electives Igneous and Metamorphic Petrology (3)

B.A. in Geological Sciences

A total of 121-124 credit hours is required.

college and university requirements (28 credit hours)

Arts and Science 1, Choices and Decisions (1)
English Composition (6)
First Year Seminar (3)
Mathematic Sciences, requirement met in major program

Distribution requirements:

Science (9), requirement met in major program
Social Sciences (9)
Humanities (9)

major program (62-66 credit hours)

mathematics (6-8 credits)
Math 21, 22 Analytic Geometry and Calculus I, II (8) **or**
Math 41, 44 BMSS Calculus I, II (6)

collateral sciences (13-14 credit hours)

Chm 21, 22	Introductory Chemical Principles and Laboratory (5)
Phy 11, 12	Introductory Physics I and Laboratory (5)
EES 31, 32	Introduction to Environmental and Organismal Biology and Lab (4) or
Biol 133	Invertebrate Zoology (3)

geological sciences (43-44 credit hours)*Courses required of all majors* (19-20 credit hours)

EES 21	Introduction to Earth Material and Processes (4) or
EES 101	Geology for Engineers (3)
EES 41	Physical Geology and Geomorphology in the Rocky Mountains (6)
EES 131	Introduction to Rocks & Minerals (3)
EES 231	Mineralogy and Crystallography (3)
EES 292	Research Seminar (1)
EES 326	Geologic Evolution of North America (3)
EES 341	Field Geology (6)

One course to be selected from each of the three following categories (9 credit hours)

Earth Structure and Tectonics

EES 122	Introduction to Plate Tectonics (3)
EES 223	Structural Geology (3)
EES 301	Introduction to Geophysics (3)

Earth History and Surficial Processes

EES 112	Geomorphology (3)
EES 113	Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 313	Depositional Environments and Facies Analysis (3)

Earth Fluids and Materials

EES 316	Hydrogeology (3)
EES 331	Economic Geology (3)
EES 334	Igneous and Metamorphic Petrology (3)
EES 376	Geochemistry of Natural Waters (3)

Electives in the major (15 credit hours)

Approved courses in Earth and Environmental Sciences or related science that comprise a coherent program in an area of particular interest to the student. Students are particularly urged to undertake an undergraduate research project (EES 291) under faculty direction.

free electives (minimum of 30 credit hours)

Courses of the student's choice selected from Earth and Environmental Sciences or any other university curriculum. These courses may be used to build a minor in another curriculum such as education, law and legal institutions, chemistry, computer science, economics, English, government, journalism or science writing, international relations, etc.

Total B.A. program credits (121-124 credit hours)*Recommended Sequence of Courses*

Fall	Spring
freshman year, fall	
EES 21 or 101 (3-4)	First year seminar (3)
Math 21 (4) or 41 (3)	Chemistry 21, 22 (5)
Physics 11, 12 (5)	Math 22 (4) or 44 (3)
English composition (3)	English composition (3)
Arts and Science 1 (1)	

sophomore year

EES 131 (3)	EES 231 (3)
EES 31, 32 (4)	Major elective (3)
Free elective (6)	Distrib. requirements (6)
Distrib. elective (3)	Free elective (3)

junior year

EES category (3)	EES category (3)
Major elective (3)	Major elective (3)
Distrib. requirements (6)	Distrib. requirements (3)
Free elective (3)	Free elective (6)
EES 292 (1)	

EES 341 (6)

*Summer**senior year*

EES category (3)	EES 326 (3)
Free elective (6)	Major elective (3)
Major elective (3)	Free elective (6)

Geology Minor (18-21 credit hours)

A minor in geological sciences may be achieved by completing the following requirements.

EES 21	Introduction to Earth Materials and Processes (4) or
EES 101	Geology for Engineers (3) or
EES 41	Physical and Historical Geology in the Rocky Mountains (6)
EES 122	Introduction to Plate Tectonics (3)
	or
EES 113	Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
EES 131	Introduction to Rocks & Minerals (3)

and, any two Earth and Environmental Sciences courses at the 100-level or above (but not EES 101). (6)

Total B.A. minor program credits 18-21 credits*Combined B.A. or B.S. and M.S. Program in Geological Sciences*

The Department of Earth and Environmental Sciences offers a combined bachelor of arts or bachelor of science and master of science program in geological sciences. Students working toward the bachelor of arts or the bachelor of science in geological sciences who are enrolled in the program are permitted to take courses that apply toward the master of science degree during their senior year. During the student's senior year, the normal undergraduate tuition will cover the costs of all courses taken, including those that are taken for graduate credit.

After receiving the bachelor's degree, students registered in the program may acquire, if eligible for admission to The Graduate School, full-time graduate status, and, as such, they may apply for appointment to a teaching or research assistantship or graduate fellowship.

The program is designed for those students who, upon completing the junior year and the field camp requirement, need less than thirty credit hours to complete work for the bachelor's degree. To be accepted into the program, students should have a superior record of academic performance.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the department faculty and the dean of Graduate Studies. The application must include: a tentative master of science program approved by the department's graduate coordinator, and a roster, also approved by the graduate coordinator, showing which courses taken during the senior year. All of the normal requirements for each degree as outlined must be fulfilled.

Students enrolled in this program should make

application for admission to full-time graduate status after completing the first semester of the senior year.

Program in Civil Engineering and Geological Sciences

The Department of Earth and Environmental Sciences, in conjunction with the Department of Civil Engineering, administers a five-year program in geological engineering that leads to a bachelor of science degree in geological sciences. This is described under the heading of Civil Engineering and Geological Sciences in the catalog.

Departmental Honors in Earth and Environmental Sciences

Students in either the B.A. or B.S. curricula may undertake a program that leads to graduation with departmental honors. To participate, the student must have an overall cumulative GPA of 3.0 or greater, must file a written request with the undergraduate instruction committee for departmental honors during his/her junior year (or, at latest, at the beginning of the first semester of her/his senior year), and must complete at least 3 credits of earth and environmental research (EES 291). An advisory committee of 3 faculty is constituted to supervise and guide the research, and to approve the required honor thesis. In addition, students present their research results and conclusions orally in a departmental seminar.

Earth and Environmental Sciences

Undergraduate Courses

7. Human Biology (3) fall

The human condition as it is related to modern science, for nonscience majors. Emphasis is given to chemistry of life, cell biology and various systems associated with *Homo Sapiens*. Pritchard

11. Environmental Geology (3)

Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes, resource limitations and development, pollution of geologic systems, environmental legislation, engineering case studies. Evenson

21. Introduction to Earth Materials and Processes (4) fall-spring

Introduction to the structure of the earth and processes of geologic change. Earth as a dynamic planet. Lecture, laboratory, and field trips. Meltzer, Myers

31. Introduction to Environmental/Organismal Biology (3)

Introduction to the structure, function, and evolution of living systems, with emphasis at the levels of organism, population, community, and ecosystem.

32. Introduction to Environmental/Organismal Biology Lab (1)

Experiments, observations, and discussions related to the principal topics covered in EES 31. Corequisite: EES 31.

41. Physical Geology and Geomorphology in the Rocky Mountains (6) summer

Geology of Wyoming and Idaho. Six weeks of morning and evening lectures; afternoon field exercises. See EES 21 and EES 112 descriptions for course content. See EES 341 description for location details. Prerequisite: Consent of Field Camp Director Evenson.

90. College Seminar (3)

101. Geology for Engineers (3)

A study of the materials that make up the earth, the physical, chemical, and environmental history that they relate, and the processes that act to change them. Designed primarily for upperclass science and engineering majors. Lectures and laboratory. Myers

112. Geomorphology (3)

Systematic study of the origin, evolution, and distribution of the earth's topographic features, land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required field trips. Prerequisite: EES 11, 21, or 101. Evenson

113. Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3) spring

Physical and chemical formation of early earth and its atmosphere; appearance of life; evolution of life forms as recorded in the sedimentary record. Environmental changes and responses to plate tectonic movements and extra-terrestrial factors. Lectures, seminars. Laboratory and field trips. Prerequisites: EES 21 or EES 101. Carson and Zeitler

122. Introduction to Plate Tectonics (3)

Theory of plate tectonics with emphasis on plate geometry, geophysical relationships and geological consequences. Lectures and laboratory. Prerequisite: EES 21, or 101. Kodama and Zeitler

131. Introduction to Rocks and Minerals (3)

Basic principles of mineralogy. Classification and origin of igneous, metamorphic, and sedimentary rocks. Lectures and laboratory. Prerequisites EES 21 or EES 101 or EES 41. Bebout

133. Introduction to Mineralogy (3)

Principles of crystallography and mineralogy; megascopic study, identification, and description of common minerals. Lectures and laboratory. Simpson

134. Introduction to Optical Mineralogy and Crystallography (3)

Fundamentals of crystallography and crystal structure; patterns and symmetries, symmetry notations; optical mineralogy and mineral identification. Lectures and laboratory. Prerequisite: EES 133. Simpson

135. Introduction to Lithology and Petrography (3) spring

Description and classification of rocks in hand specimens and thin sections. Lectures and laboratories. Prerequisites: EES 133 and 134 (may be taken concurrently).

162. Non-Vascular Plants (3)

A comparative study of the ontogenetic and phylogenetic development of algae, fungi, and bryophytes. The life cycles and ecological importance of representative organisms are examined. Two lectures and one laboratory. Prerequisite: EES 31, 32. Pritchard

163. Evolution of Vascular Plants (3)

A comparative study of the ontogenetic and phylogenetic development of algae, fungi, and bryophytes. The life cycles and ecological importance of representative organisms are examined. Two lectures and one laboratory. Prerequisite: EES 31. Pritchard

181. Introduction to Earth and Life Systems (4)

Survey of interactions between life and earth systems, with emphasis on both modern systems and their evolution at geological time scales. Study of systems theory, major biogeochemical cycles, community and ecosystem dynamics, and climate and associated feedbacks. Lecture, laboratories, and computer exercises. Prerequisites: EES 31, 32 and EES 21 or EES 101 or EES 41. Staff

213. Sedimentology and Stratigraphy (3)

Processes of sediment transport, deposition, and diagenesis of clastic and non-clastic sediments; sedimentary textures and structures; lithostratigraphy and stratigraphic correlation using biologic, magnetic, seismic, and radiometric methods. Lectures and laboratories. Prerequisites: EES 113 or consent of departmental chairman. Carson

223. Structural Geology (3) fall

Application of basic concepts of stress, strain, and material properties to the study of folds, faults, fabrics, and other deformational structures in the earth's crust. Introduction to geometrical and field techniques. Lectures, laboratories and field trips. Prerequisites: An introductory geology course. Anastasio

231. Mineralogy and Crystallography (3)

Fundamentals of mineralogy and crystallography. Optical mineralogy and mineral identification. Introduction to minerals in thin section. Lectures and laboratory. Prerequisite: EES 131.

251. Ecology (3)

Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisites: EES 31, 32. Williamson

252. Ecology Laboratory (1)

Laboratory and field trips related to ecological topics covered in EES 251. Prerequisite: EES 251, preferably concurrently.

291. Earth and Environmental Research (1-3)

Independent investigation of a special problem in the field laboratory, or library. May be repeated for credit up to a 12-credit maximum. Prerequisite: consent of chairperson.

292. Research Seminar (1) spring

Introduction to research in the Earth and Environmental Sciences. Course open only to juniors and seniors with declared majors in environmental science, geological science, geophysics and ESRM. May be repeated for credit up to a 2-credit maximum. Staff

293. Writing in Environmental and Organismal Biology (3)

A course designed to acquaint students with scientific writing as it pertains to environmental, medical and biological literature. Students are introduced to the primary literature, the scientific method and current practices with respect to journal writing. A review paper on a life science topic is required. Prerequisite: consent of the department.

Advanced Undergraduates and Graduate**Students****301. Introduction to Geophysics (3)**

Gravitational, magnetic, seismic, electrical, and thermal properties of the earth. Interpretation of field measurements to resolve crustal and near-surface earth structure. Lectures and laboratories. Prerequisites: Math 21, Phys 21, EES 223, or consent of instructor. Kodama and Meltzer

302. Solid Earth Geophysics (3)

Study of rotation and figure of earth, global seismology and internal structure of the earth, heat flow and convection, geomagnetism, geodynamics, and planetology. Prerequisites: Math 21, Phys 21. Kodama and Meltzer

306. Geophysical Field Techniques (3)

Geophysical field investigation in an area of geological interest. Theory and application of seismic, gravity, magnetism, and electrical methods; data collection, interpretation, and written reports. Prerequisites: EES 301 or consent of department chairperson. Kodama

307. Case Histories in Engineering Geology (3)

Methods of geological investigation at engineering sites. Assessing suitability of a proposed site, acquiring geological information for proper engineering design, and recognizing potential geotechnical problems during and after construction. Prerequisites: Open to all majors in the Department of Earth and Environmental Sciences, Civil Engineering, or students who have successfully completed 6

credit hours of Earth and Environmental Science at or above the 100 level, excluding EES 101. Myers

308. Seismic Data Analysis (3)

The use of seismic reflection data to determine earth structure and properties. Course emphasizes seismic experiment design, data processing and techniques (signal processing), and application of interpretation procedures to address geologic questions. Students are expected to complete a processing and interpretation project including the integration of surface and subsurface geologic data with the seismic reflection profiles. Prerequisites: EES 301 or permission of the instructor. Meltzer

309. Environmental Magnetism (3)

The use of earth material magnetic properties to study environmental systems. Specific examples include: Determining the flux and source of lake and marine sediments. Techniques of magnetic measurements, characteristics of the Earth's magnetic field, and mineral magnetism will also be discussed. Prerequisites: EES 21, or EES 101. Kodama

313. Depositional Environments and Facies Analysis (3)

Interpretation of sedimentary records on the basis of sedimentary rock composition and structures; characteristics of continental, continental margin, and marine deposits; facies as indicators of source, depositional environment, and tectonic setting; principles of basin analysis and sequence stratigraphy. Lectures, laboratories, and field trips. Prerequisites: EES 113, EES 131, and EES 213. Carson.

315. Soil Genesis (3)

Genesis, classification and application of pedology. Weathering of parent materials; chemistry of soils; geologic, biologic, and climatic controls on soil formation; application to geologic and engineering concepts. Lecturers and two all-day field trips. Prerequisite: EES 213 or consent of the department chairperson. Evenson, Myers

316. Hydrogeology (3)

Interrelationships of geologic materials and processes with water; entry, storage, interaction, and flow of water through permeable earth materials; evaluation, development, and management of ground-water resources. Prerequisites: EES 21, or 101. Myers

319. Evaluation and Management of Ground-Water Resources (3)

Use of spatial database system (ARC/INFO) in the storage and manipulation of data necessary for the evaluation and management of ground-water systems. Prerequisite: EES 316 or equivalent. Myers

324. Structural Analysis (3)

Field methods emphasizing interpretation of minor structures and practical application of geologic strain and petrofabric analysis applied to regional geologic problems. Seminars, laboratories, and field trips. Prerequisites: EES 223. Anastasio

326. Geologic Evolution of North America (3)

A senior seminar on the lithologic, tectonic, and morphologic evolution of North America; developed within the framework of the plate tectonic theory. Anastasio and Myers

331. Economic Geology (3)

The formation of mineral deposits and the occurrence and characteristics of deposits of economic importance. Includes metals, nonmetals and fuels. Lectures, laboratory work and inspection trips. Prerequisite: EES 21.

334. Igneous and Metamorphic Petrology (3)

Petrogenesis of igneous and metamorphic rocks and their distribution in space and time as related to past and present plate tectonic events. Microscopic study of rock suites.

Lectures and laboratory. Prerequisite: EES 131, EES 231. Bebout

336. Mineral Phase Relations (3)

Principles of phase equilibria; unicomponent and multicomponent condensed systems and multicomponent systems with volatile phases. The application of phase relation studies to mineralogical and geological problems. Prerequisites: EES 133 and EES 134 or EES 231. Lectures and laboratory. Simpson

337. X-ray Diffraction of Materials (3)

Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Prerequisite: consent of department chairperson.

338. Electron Microscopy and Microanalysis (4)

Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson.

339. Applied Mineralogy (3)

Methods and approaches to the solution of industrial and environmental problems employing modern mineralogical techniques, especially transmitted- and incident-light polarizing microscopy and X-ray powder diffraction. Case histories of interest to geologists, chemists, ceramists, chemical, metallurgical, and mineral engineers, environmental engineers, and materials scientists. Lectures and laboratory. Prerequisites: EES 134 or EES 231 or consent of the instructor. Simpson

341. Field Geology (6) summer

Field study and geologic mapping of sedimentary, igneous, metamorphic, and glacial deposits in the Rocky Mountains of northwestern Wyoming, and southeastern Idaho. Additional short studies in the Badlands and Black Hills of South Dakota, the Grand Tetons, Yellowstone Park, Craters of the Moon Park, and other areas in the Rocky Mountain region. Six weeks in the field. Summer session. Prerequisite: consent of the department chairperson. Graduate credit not given for this course. Evenson, Myers

351. Aquatic Ecology (3)

Physical, chemical and biological aspects of freshwater environment, including cyclic and seasonal changes. Major groups of organisms and their interactions. Prerequisites: EES 31, 32.

352. Aquatic Ecology Laboratory (1)

Field-oriented investigations of the physical, chemical, and biological characteristics of lakes and streams related to topics covered in EES 351.

361. Animal Physiology (3)

Structure and function of animals at the level of tissues, organs, organ systems, and whole organisms interacting with the environment. Prerequisite: EES 31, 32 and at least one semester each of physics and chemistry. Hargreaves

362. Animal Physiology Laboratory (1)

Laboratory investigation of structure and function of organs and intact animals, in relation to topics covered in EES 361. Prerequisite: EES 361, preferably concurrently. Hargreaves

373. Geochemical Thermodynamics (3)

Macroscopic chemical thermodynamics with applications to geochemical processes. Thermodynamic relationships, geochemical equilibria, and an introduction to kinetics. Prerequisites: EES 133 and Chm 31. Moses

374. Isotope Geochemistry and Geochronology (3)

The use of radiogenic isotopic systems to determine the age, temperature history, and chemical evolution of rocks. Principles and applications of stable-isotope geochemistry. Radioactive decay and isotope systematics. Diffusion and fractionation effects. Lectures, seminars, and laboratories. Prerequisites: Math 21, Chm 21, EES 131, or consent of instructor. Zeitler and Bebout

375. Water-Rock Interaction Seminar (1)

Discussions of current and "classic" literature in water-rock interactions, selected and presented by participants. Brief writing exercises. Prerequisite: EES 171 and consent of instructor. Moses

376. Geochemistry of Natural Waters (3)

Introduction to aqueous geochemistry. Applications of: thermodynamics, mass balance, system analysis, kinetics to understanding water-rock interactions and biogeochemical cycles. Laboratories emphasize computations and geochemometrics. Prerequisites: two semesters of chemistry, two semesters of calculus, and EES 131. Moses

381. Senior Seminar in Environmental Science (3)

Advanced examination and discussion of current issues in environmental science. Work will include readings from the technical literature, student presentations and reports, and some combination of field, laboratory, and computer projects. Course enrollment limited to senior majors in environmental science. Staff

382. Statistical Applications in Earth and Environmental Sciences (3)

Univariate and bivariate statistical models with specific reference to geological, hydrological, and biological field and laboratory studies. Analysis of variance, applications of the Chi-square distribution, analysis of covariance, linear, nonlinear and multiple regression, and distribution-free methods. Carson

383. Environmental Data: Acquisition, Analysis, and Management (3)

Acquisition, analysis and management of environmental datasets with emphasis on aquatic ecosystems and electronic tools. Data from a variety of computer-controlled and programmable field instruments, and from existing databases available through computer networks. Lectures and laboratories. Prerequisites: EES 181, CSc 11 or other introduction to computer programming, and departmental approval. Hargreaves.

For Graduate Students

The Department of Earth and Environmental Sciences offers graduate degree programs leading to the MS or PhD in Geological Sciences and in Environmental Science. Research is an important and integral part of the graduate programs; a student selects a research problem through consultation with one's adviser. Graduate students make annual presentations of their research to the department. M.S. students complete 30 credits of coursework and present a written thesis reporting their investigation of a specific problem. Candidates for the Ph.D. must pass a qualifying examination administered by an examination committee prior to the start of an individual student's second semester and the general examination, which includes the public oral defense of the written dissertation proposal, prior to the end of the student's third semester; Ph.D. candidates also defend their written dissertation at a public oral presentation. All graduate students work with an adviser who chairs the individual student's supervisory committee. In addition, each graduate student must take two of the department's three graduate core courses (EES 415, 426, and 484). For

details beyond the following summary, please contact the department.

Program in Geological Sciences. The department's Geological Sciences program emphasizes studies of the Earth's crust in both tectonic and surficial regimes. Graduate research in the Geological Sciences program is oriented toward geological processes in the general areas of structural geology, metamorphic petrology, isotope geochemistry, sedimentation, glacial and Quaternary geology, geomorphology, paleomagnetism, reflection seismology, aqueous geochemistry, hydrogeology, and geochronology. Aside from the core-course requirement, course selection is determined by the student in consultation with the supervisory committee.

Program in Environmental Science. The department's Environmental Science program stresses the interaction of biotic and abiotic components as the basis for understanding natural environmental systems. Process- and system-oriented graduate research opportunities in Environmental Science include sedimentation, glacial and Quaternary geology, environmental physiology, environmental magnetism, microbial ecology, aqueous geochemistry, hydrogeology, and plankton ecology. Three types of course programs are available, providing concentrations of Environmental Biology or Surficial Processes or providing more general training in Environmental Science. In addition to completing the department's core course requirement, students opting for a concentration must complete three of the designated courses in either Aquatic Ecosystems or Surficial Processes and one designated course in the other category, while students seeking general training in Environmental Science take two courses from each category. All students in the Environmental Science program must take a course in quantitative methods. M.S. theses are defended in a public oral presentation.

Special departmental research facilities of interest include: Philips APD-3600 automated X-ray powder diffractometer; Philips AXS automated X-ray fluorescence spectrometer, Debye-Scherrer X-ray powder camera; complete petrography and incident-light microscopy facilities; hydrothermal apparatus for experimental mineralogy; belt-type ultra-high-pressure apparatus for upper mantle studies; complete laboratory for noble-gas and fission-track geochronology, including a low-blank, double vacuum resistance furnace and a VG Isotopes model 3600 mass spectrometer; paleomagnetism laboratory with a Molspin spinner magnetometer, a 2-Axis CTF Cryogenic Rock Magnetometer, a Schonstedt tumbling AF demagnetizer, and a Schonstedt thermal demagnetizer; reflection seismology laboratory with Apollo computer workstation for seismic processing and Bison DIFP multi-channel x seismograph; sedimentation laboratory equipped with Particle Data computer-based particle-size analyzer and rapid sediment analyzer; field geophysical equipment including Bison shallow refraction seismic unit and Bison shallow resistivity apparatus, master Wordon gravimeter, Geometrics portable proton precession magnetometer; Keck borehole logging equipment including caliper, natural gamma, electrical resistivity, and self-potential probes; downhole geochemical sampling equipment; Waters computer-assisted ion chromatograph; ARL 34000 inductively-coupled plasma atomic emission spectrometer (ICP/AES); NETZSCH DTA/tga analyzer; Sun graphics workstations which support CADD, mapping/contouring software, and ARC/INFO geographic information system; standard equipment for field mapping.

Three wells are also located on campus as an *in situ* groundwater laboratory. Students perform a variety of pump tests, geochemical sampling, and down-hole geophysical determinations at this facility.

The following major analytical facilities are available on campus to students and staff of the department: fully automated JEOL 733 electron microprobe, Philips 300 electron microscope completely equipped for transmission and diffraction, ETEC scanning microscope completely equipped for quantitative X-ray microanalysis and electron energy-loss spectroscopy; and Perkin Elmer double-beam infrared spectrophotometer.

Equipment to conduct environmental biology research is also available in the department. This includes, but is not limited to, computers, microscopes, environmental chambers, centrifuges, sampling nets, current meters, incubators, and autoclaves. A remotely operated vehicle (ROV) fitted with a video camera can be used to monitor plankton behavior and dynamics in aqueous environments. The department also has the Pocono Comparative Lakes Program (PCLP), an interactive research and educational program, to study lake systems through multidisciplinary research and to provide training for undergraduate and graduate students. The program is centered at the Lacawac Sanctuary in the Pocono Mountains and focuses on three "core" lakes that serve as model systems for experimental and comparative studies on aquatic communities and ecosystems. For more information about the PCLP, please contact Prof. Williamson (215-758-3660).

405. Paleomagnetism (3)

Characteristics and history of the earth's magnetic field, rock magnetism, field and laboratory techniques, statistical analysis of paleomagnetic data, tectonic and geochronologic applications of paleomagnetism. Prerequisite: Phys 21. Kodama

407. Seismology (3)

Principles of elastic wave initiation, propagation, reflection, and transmission in ideal media and earth materials, and techniques used to image earth structure. Course includes: seismic theory, elasticity, body and surface waves, geometry and raypaths, properties of earth techniques. Prerequisites: Math 205, recommended Math 322 (may be taken concurrently), Phys 21, EES 21, or permission of the instructor. Meltzer

414. Glacial and Quaternary Geology (3)

Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Consent of instructor. Evenson

415. Quaternary Dating and Paleoclimatology (3)

Quaternary climates and review of methods used to reconstruct and date past climatic variation. Types of proxy data available, the methods used in their analysis and interpretation, assumptions and limitations of the dating methods. Prerequisite: graduate standing in EES. Staff

417. Advanced Glacial Geology (3)

Seminars on advanced topics in glacial geology; review of classic and contemporary literature. Topics include dynamics of glacier movement, glacial landforms and deposits, glacial stratigraphy. Field trips. Prerequisite: EES 414 or consent of the department chairperson. Evenson

418. Advanced Geomorphology (3)

Lectures and seminars on advanced topics in geomorphology. Field trips. Prerequisite: EES 112 or consent of the department chairperson. Evenson

426. Tectonic Processes (3)

Current models of tectonic processes in intraplate settings and at plate boundaries. Critical evaluations by the class of the geological, geochemical and geophysical data sets which gave rise to these models. Prerequisites: graduate standing in EES, or consent of department chairperson. Staff

427. Thrust Belts (3)

Geometry and mechanics of thrust belts and structural tools necessary to study orogenesis. Topics include thrust and normal faults, folds, minor structures, basement-cover problems, the plutonic and metamorphic hinterland, and foreland basins. Structures are placed in regional context: Andes, Appalachians, Caledonides, Himalayas, North America Cordillera, Pyrenees, or Western Alps. Lectures and field trips, including one long one. Prerequisite: EES 223 or equivalent. Anastasio

428. Stress and Strain in Rocks (3)

Theory of continuum mechanics and application to analytical methods of geological strain analysis; rock material properties and micro-mechanisms of rock deformation; tectonic fabric development; kinematic analysis. Lectures and laboratories. Prerequisite: EES 223 or equivalent. Anastasio

429. Principles and Applications of Thermochronometry (3)

Determination of the thermal history of crustal rocks using geochronological and other methods. Diffusion and kinetics; application of the closure-temperature concept of geochronological and petrological systems. Determination of metamorphic P-T-t paths, determination of temperature histories using such methods as vitrinite reflectance, and integration of such data with geochronological results. Applications to igneous, metamorphic, and sedimentary realms. Lectures, seminars, laboratories. Prerequisite: EES 374 or equivalent, or consent of instructor. Zeiler

437. Advanced Igneous Petrology (3)

Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory and field trips.

438. Advanced Metamorphic Petrology (3)

Processes involved in the transformation of rock masses under high pressure and temperature. Problems of the deep crust and upper mantle. Lectures, laboratory and field trips.

451. Advanced Ecology (3)

Seminars, conferences and directed field work with emphasis on theoretical models and their application to real biological systems. May be taken more than once for credit. Prerequisite: EES 251 or equivalent. Williamson

452. Community Ecology (3)

Current concepts in the ecology of animal communities. Theoretical and experimental approaches to understanding the primary factors which regulate the structure and dynamics of communities. Prerequisite: EES 251 or equivalent. Williamson

461. Comparative Animal Physiology (3)

Lectures and seminars on selected areas in the comparative physiology of animals. Introduction to the current literature of subjects studies. These include mechanisms of osmotic control, temperature effects, nerve and muscle physiology and others. Prerequisite: EES 361. Hargreaves

462. Cytochemistry (3)

A study of morphological and biochemical events during cell growth and differentiation including lectures, laboratories, and student reports on current literature. Prerequisite: consent of the department chairman.

463. Marine Botany (3)

A study of the morphological, physiological, biochemical and ecological features of those plants found primarily in the salt water environment. Emphasis is placed on the evolutionary and ecological significance of the phytoplankton, benthic algae and rooted aquatic plant divisions associated in and near the oceans. The economic importance of these plants is considered. Laboratory work, field work and library searches and reports.

473. Aqueous Geochemistry (3) spring (alternate even years)

Advanced study of physical and inorganic aqueous geochemistry, including homogeneous and heterogeneous equilibria, kinetics, and surface processes in water-rock systems. Computational modeling of water-rock systems. Prerequisites: EES 171 or equivalent, computer programming (C, Pascal, or Fortran), and consent of instructor. Moses

484. Aquatic Ecosystems (3) fall (alternate even years)

Theoretical and experimental approaches to understanding physical and chemical influences in aquatic environments on organisms and their community, population, and systems

ecology. Field trip. Pass/fail grading. Prerequisite: graduate standing in EES. Staff

491. Investigations in Earth and Environmental Sciences (1-6)

Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

492. Advanced Topics in Modern and Quaternary Processes (1-6)

Intensive study of topics in Modern and Quaternary geology not covered in more general courses.

493. Advanced Topics in Tectonics (1-6)

Intensive study of tectonic processes and products not covered in more general courses.

494. Advanced Topics in Aquatic Ecosystems (1-6)

Intensive study of aquatic ecosystems not covered in more general courses.

East Asian Studies

Raymond Wylie, Ph.D. (London, England), professor of international relations and director, East Asian studies. **Professors.** John Gatewood, Ph.D. (Illinois), *Social Relations*; Norman Girardot, Ph.D. (Chicago), *Religion Studies*; Michael Notis, Ph.D. (Lehigh), *Materials Science and Engineering*; Raymond Wylie, Ph.D. (London, England), *International Relations*.

Associate professors. Kenneth Kraft, Ph.D. (Princeton), *Religion Studies*; David Pankenier, Ph.D. (Stanford), *Modern Foreign Languages*.

Assistant professors. Constance Cook, Ph.D. (U.C., Berkeley), *Modern Foreign Languages*; Gail Cooper, Ph.D. (U.C., Santa Barbara), *History*; Nicola Tannenbaum, Ph.D. (Iowa), *Social Relations*.

Lecturers. Kiri Lee, M.A. (Harvard), *Modern Foreign Languages*.

The East Asian studies program affords undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of East Asia, broadly defined, i.e., China, Japan, Korea, Southeast Asia and the Pacific. The program encompasses the rich historical and cultural heritage of the countries of East Asia, as well as their growing importance in world affairs and their critical relationship to the national interests of the United States.

The major in East Asian studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 35 credits. Chinese or Japanese language to intermediate level (2 years) is required, in addition to other courses in the humanities and social sciences. The major is based on an approved list of courses in East Asian studies, chosen in consultation with the major advisor, Professor David Pankenier, Modern Foreign Languages, 505 Maginnes Hall, 758-3090.

The minor in East Asian studies is composed of a minimum of 15 credits in East Asian studies, chosen from an approved list in consultation with the minor advisor, Professor Constance Cook, Modern Foreign Languages, 519 Maginnes Hall, 758-3091.

Additional courses are offered at other LVAIC institutions and may be taken for credit by Lehigh students. In addition, students may avail themselves of a variety of extracurricular activities that are offered in East Asian studies, such as special lectures and seminars, films, performances and exhibits.

Students are encouraged to spend a summer, semester or year abroad in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Subject to prior approval, credits acquired abroad can be transferred back to Lehigh. For details on various programs currently available, consult Dr. Karen Keim, Study Abroad Coordinator, 539A Maginnes Hall, 758-3351.

The program cooperates with the IVAIC East Asia Seminar, which meets four times a year (twice a semester) to discuss current research in various fields. While the seminar primarily involves faculty, East Asian studies majors and minors are also encouraged to participate. The seminar coordinator is Professor Nicola Tannenbaum, Social Relations, 11 Price Hall, 758-3829.

The overall program is administered by the East Asian Studies Committee, an interdisciplinary body of faculty members with a special interest in the region. This committee oversees both the formal academic work within the program as well as the extracurricular activities sponsored at the university. It also cooperates with the Asian Cultural Association, and other campus organizations involved in some aspect of East Asian studies.

The courses listed are regularly offered in the program and new ones are currently under development in a number of subject areas. (Consult the Registrar's *Schedule of Classes* for specific offerings in any particular semester.)

For further information, interested students should consult Professor Raymond Wylie, Director, East Asian Studies Program, 208 Maginnes Hall, 758-3389/3390 or any of the East Asian faculty listed above.

Major in East Asian Studies

The East Asian studies major is designed to accomplish three goals: to ground the student in a regional language and culture (Chinese or Japanese); to survey various disciplines in East Asian studies more broadly; and to provide advanced language and research opportunities in the upperclass years. The program, when completed successfully, will prepare the student for further graduate work, professional education, or employment in the public or private sector. There is an increasing demand for graduates who combine a major in a disciplinary field (e.g., economics, international relations) with a second major (or minor) in East Asian studies, including Chinese or Japanese language competence.

The major in East Asian studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 11 courses (35 credits). The distribution of the credits is as follows, subject to the guidance of the academic advisor, Professor David Pankenier, Modern Foreign Languages, 505 Maginnes Hall, 758-3090. Full descriptions of all East Asian studies courses are provided in the listings of individual departments.

I. Core Requirements

A. *Language and Culture*: Chinese or Japanese to intermediate level (2 years); 4 courses (14 credits), variable, based on placement, chosen from the following*:

Chin 1	Elementary Chinese I (4)
Chin 2	Elementary Chinese II (4)
Chin 11	Intermediate Chinese I (3)
Chin 12	Intermediate Chinese II (3)
Jpns 1+	Elementary Japanese I (4)
Jpns 2+	Elementary Japanese II (4)
Jpns 11+	Intermediate Japanese I (3)
Jpns 12+	Intermediate Japanese II (3)
MFL 91	Elementary Chinese Language and Culture Abroad (6)
MFL 191	Intermediate Chinese Language and Culture Abroad (6)

*Note 1. Students with prior knowledge of Chinese or Japanese will be placed on the basis of a competence test. Native speakers placing out of the language requirement in part or in whole will be required to take additional East Asian studies courses to make up a minimum of 35 credit hours.

+Note 2. Courses in Japanese language are offered at Lafayette College and at Lehigh (Modern Foreign Languages Department provisional program). Until Lehigh courses in Japanese become permanently established, students planning to complete at Lehigh the language component of the Japanese studies concentration should obtain the consent of the MFL department chairperson.

B. *Humanities*: 2 courses (6 credits) chosen from the following:

MFL 72	Chinese Literature in Translation (3)
MFL 73	Introduction to Chinese Culture (3)
MFL 74	Chinese Cultural Program (3-6)
MFL 75	Chinese Civilization (3)
Rel 90	Great Books of Asian Religions (3)
Rel 110	Buddhism in the Modern World (3)
Rel 115	Religions of China (3)
Rel 117	Religions of Japan (3)
Rel 118	Zen Buddhism (3)
Rel 136	The Taoist Tradition (3)
Rel 164	Japan's Response to the West (3)
Rel 166	Introduction to Japanese Civilization (3)

C. *Social Sciences*: 2 courses (6 credits) chosen from the following:

Anth 184	Cultures of the Pacific (3)
Anth 186	Peoples of Island Southeast Asia (3)
Anth 188	Peoples of Mainland Southeast Asia (3)
Hist 31	History of Japanese Industrialization since 1800 (3)
Hist 176	Topics in East Asian History (3)
IR 61	East Asian International Relations (3)
IR 162	China in World Affairs (3)
IR 163	Japan in World Affairs (3)
STS 141	Science and Technology in East Asia (3)

D. *Senior Seminar*:

IR 364	Seminar in the International Relations of East Asia/Pacific Rim (3)
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II. Advanced Electives

Two courses (6 credits) chosen from the following, 1 course (3 credits) of which must be at the 300 level:

A. *Language and Culture*:

Chin 141	Advanced Chinese I (3)
Chin 142	Advanced Chinese II (3)
Chin 151	Modern Chinese Fiction (3)
MFL 291	Advanced Chinese Language and Culture Abroad (3)

B. *Humanities*:

Rel 220	Classics of Asian Religions (3)
Rel 221	Topics in Asian Religions (3)
Rel 361	Fieldwork (3)
Rel 371	Special Topics (1-3)

C. *Social Sciences*:

Anth 339	Seminar in Anthropology (3)
Hist 371	Special Topics in History (1-3)
Hist 372	Special Topics in History (1-3)
IR 371	Reading in International Relations (3)
IR 372	Reading in International Relations (3)
IR 375	Internship in International Relations (1-3)
IR 391	Special Topics (3)
IR 392	Special Topics (3)
SR 371	Special Topics in Social Relations (1-3)
SR 372	Special Topics in Social Relations (1-3)

D. Other suitable courses at IVAIC or other approved institutions in the United States.

E. Other suitable courses in approved study abroad programs in East Asia.

Minor in East Asian Studies

The minor in East Asian studies is intended as a complement to a student's major field of study, and it is flexible according to individual needs. Students are free to survey the field broadly or concentrate in a special area such as Chinese or Japanese studies. The minor is composed of a minimum of 5 courses (15 credits) in East Asian studies, chosen from an

approved list in consultation with the minor advisor, Professor Constance Cook, Modern Foreign Languages, 519 Maginnes Hall, 758-3091.

Study Abroad Programs

Students are encouraged to spend a summer, semester or year in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Students who wish to study abroad, and who wish to have the academic work taken in that program count toward a Lehigh degree, must have a GPA of 2.7 or higher. Any student with a lower GPA may appeal to the Study Abroad Committee for an exception to this rule before applying to an approved study abroad program. These programs are open to all LVAIC students subject to the regulations of their home institutions. For details on all programs, consult Dr. Karen Keim, Study Abroad Coordinator, 539A Maginnes Hall, 758-3351.

Economics

Professors. J. Richard Aronson, Ph.D. (Clark), *Clayton Professor*; Nicholas W. Balabkins, Ph.D. (Rutgers); Alvin Cohen, Ph.D. (Florida); Thomas J. Hyclak, Ph.D. (Notre Dame); Jon T. Innes, Ph.D. (Oregon), *major advisor and curriculum director*; Arthur E. King, Ph.D. (Ohio State); John R. McNamara, Ph.D. (Rensselaer); Vincent G. Munley, Ph.D. (S.U.N.Y.); Warren A. Pillsbury, Ph.D. (Virginia); Robert J. Thornton, Ph.D. (Illinois), *chairman, MacFarlane Professor*. **Associate professors.** Colleen M. Callahan, Ph.D. (North Carolina); James Dearden, Ph.D. (Penn State); Frank R. Gunter, Ph.D. (Johns Hopkins); Anthony O'Brien, Ph.D. (Berkeley); Larry W. Taylor, Ph.D. (North Carolina). **Assistant professors.** Darlene Chisholm, Ph.D. (Washington); Mary Deily, Ph.D. (Harvard); Judith McDonald, Ph.D. (Princeton); Todd Watkins, Ph.D., (Harvard). **Active emeriti.** Finn B. Jensen, Ph.D. (Southern California); Eli Schwartz, Ph.D. (Brown).

Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19th century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life . . . a part of the study of man." This dual nature of economics, technical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Science as well as in the College of Business and Economics.

As the description below suggests, the economics program is exceptionally flexible once one moves beyond the sophomore year. This flexibility allows the major to be adapted easily to the needs of students with widely varying goals. Although many students choose the economics major in order to secure a firm foundation in economics and finance before entering the business world, many others choose it in preparation for law school or as a complement to their major in government, history, international relations, journalism, mathematics, urban studies, or other disciplines. Naturally, many students who major in economics do so with the intent of pursuing graduate work at the master's or doctor of philosophy levels; others simply want to become "economically literate" in a world where such literacy is increasingly in demand.

At the same time that the program provides flexibility, it also consists of a substantial core of economic theory and related courses. This assures that the student who is uncertain concerning career goals will obtain a broad education in economics and business no matter what upper-level courses are chosen.

Students who are interested in designing a major program in economics suitable to their needs should consult with the major advisor and curriculum director. The requirements

for the major and minor programs listed below pertain to the graduating classes of 1996 and later.

Major in College of Business and Economics

Students in the College of Business and Economics electing to major in economics must take the College core courses as listed in the College of Business and Economics section of this catalog. They must also take Eco 119 and at least 12 credit hours of 300 level economics courses beyond the core requirements. These courses may be chosen so as to form an area of specialization or to provide a broad exposure to the various aspects of the discipline. In any case, students should consult with the major advisor (Prof. Jon Innes) in forming their programs.

Major in College of Arts and Science

Required Courses (30 credits)

Eco 11, 12	Principles of Microeconomics (3) and Principles of Macroeconomics (3)
Math 41, 44*	BMSS Calculus I and II (6)
Acct 151**	Introduction to Financial Accounting (3)
Eco 105	Intermediate Microeconomic Analysis (3)
Eco 119	Intermediate Macroeconomic Analysis (3)
Eco 145	Statistical Methods (3)
Eco 229	Money and Banking (3)
Fin 225**	Business Finance (3)

*Students who wish to take mathematics beyond calculus or are considering graduate work in economics should substitute Math 21, 22, and 23 for this requirement.

**Management I (Introduction to Business Computing) is a prerequisite for Acct 151 and Fin 225.

Elective Courses (12 credits)

Students must take 12 credit hours of 300 level economics courses beyond the requirements listed above. One upper-level finance course may be substituted for an economics course with the approval of the major advisor.

Minor in Economics

A minor in economics consists of 12 credit hours beyond Economics 11 and 12. Required courses in the minor are: Economics 105 or 115, 119 or 229, and two elective courses. Elective courses must be chosen from among the 300-level economics offerings. This minor is available only to students in the College of Arts and Science and in the College of Engineering and Applied Science. Interested students should contact Prof. Vincent Munley.

Undergraduate Courses In Economics

1. Economics (4)

A one-semester course in the principles of economics. General topics covered are: the determination of national income; the determination of relative prices; money and banking; monetary and fiscal policy; and government finance. (Not available for credit to students who have taken Eco 11 or 12.)

11. Principles of Microeconomics (3)

This course is an introduction to basic economic concepts, theory, and institutions. It emphasizes the application of economic analysis to a variety of problems. Topics include supply and demand; consumer choice and behavior; pricing and production decisions of firms; the role of government in the economy; labor markets and unions. (Not available for credit to students who have taken Eco 1.)

12. Principles of Macroeconomics (3)

This course extends the application of economic analysis to the macroeconomy. Topics include the measurement and determination of national output; the banking system and money supply; monetary and fiscal policy; unemployment

and inflation; international trade and the balance of payments. (Not available for credit to students who have taken Eco 1.)

101. (Mgt 101) Introduction to Quantitative Methods (3)
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics. Prerequisites: Eco 1, or Eco 11 and 12.

105. Intermediate Microeconomic Analysis (3)
Determination of prices in terms of the equilibrium of the business enterprise and consumer choice in markets of varying degrees of competition; analysis of market structures; determination of wages, rent, interest and profits. Prerequisites: Eco 1, or Eco 11 and 12. (Not available for credit to students who have taken Eco 115.)

115. Applied Microeconomic Analysis (3)
The application of economic analysis to managerial and public policy decision making. Prerequisites: Eco 1, or Eco 11 and 12. (Not available for credit to students who have taken Eco 105.)

119. Intermediate Macroeconomic Analysis (3)
Macroeconomic measurement, theory and policy. The use of alternative macroeconomic models to analyze the level of national income, inflation, unemployment, economic growth; the balance of payments, and exchange rate determination. Prerequisites: Eco 1, or Eco 11 and 12.

132. (Gov't 132, Hist. 132, and I.R. 132) An Introduction to Canada (3)
An interdisciplinary, team-taught course focusing on history, politics, economics and international relations. Topics covered include Canada's historical development, recent politics and foreign policy, and economic trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States. Prerequisites: Eco 1, or Eco 11 and 12.

145. Statistical Methods (3)
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, regression and correlation, analysis of variance, nonparametric tests, and index numbers. Prerequisites: Eco 1, or Eco 11 and 12.

For Advanced Undergraduates And Graduate Students

229. Money and Banking (3)
A course dealing with the nature and functions of money, money markets, and commercial and central banking. Effects of the interest rate and money supply on economic activity. Examination and evaluation of current and past monetary policies. Prerequisites: Eco 1, or Eco 11 and 12.

303. Economic Development (3)
The principal determinants of economic development theories are examined. Most of the theories are applicable to both the advanced industrial societies and to the poorer nations, but the emphasis is on the developmental process of the countries of the Third World. Prerequisites: Eco 1, or Eco 11 and 12. Cohen

305. The Economic Development of Latin America (3)
The course examines the forces at work in the development process in Latin America. Variables considered include the social and political as well as the economic ones. Theories are presented along with their application via the examination of country case studies. Prerequisites: Eco 1, or Eco 11 and 12. Cohen

309. Comparative Economic Systems (3)
An analysis of the economic, institutional, and political

dimensions of non-market economies in the Soviet Union and China. Prerequisites: Eco 1, or Eco 11 and 12. Balabkins

310. Economic Evolution (3)
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Prerequisites: Eco 1, or Eco 11 and 12. Balabkins

311. Environmental Economics (3)
Resource allocation implications of environmental degradation. Analysis of the benefits and costs associated with alternative pollution control programs and strategies. Prerequisite: Eco 105. Munley.

312. Urban Economics (3)
The analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity. Prerequisites: Eco 1, or Eco 11 and 12. Pillsbury

313. History of Economic Thought (3)
Study of the evolution of economic science. Critical analysis of the contributions of major economists from the 18th through the 20th centuries. Prerequisites: Eco 1, or Eco 11 and 12. Cohen, Balabkins

314. Energy Economics (3)
The economic theory of natural resource allocation over time. Economics of exhaustible and renewable resources. Environmental effects of energy production and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. Prerequisite: Eco 105. McNamara

315. Industrial Organization (3)
Structure of American industry. Development of economic models to describe behavior in markets with varying degrees of competition. Technological innovation, relationship between industry concentration and rates of return on capital, role of information and advertising, dynamics of monopoly and oligopoly pricing. Prerequisite: Eco 105. Chisholm, Deily

331. Business History (3)
The historical context of the development of the modern business firm in the United States. The roles of entrepreneurship, economic structure, technology, and government policy in the shaping of current business practices. Prerequisites: Eco 105 and 119 (Eco 145 is recommended). O'Brien

332. (Fin 332) Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 229. Innes, O'Brien

333. Managerial Economics (3)
Models of managerial decision making. Emphasis on the application of economic theory to a variety of business problems. Case studies are employed. Prerequisites: Eco 105 and 145 and Math 41 and 44 (or equivalents) or consent of instructor. McNamara

334. Labor-Management Relations (3)
An analytical study of the U.S. system of industrial relations, including the evolution of the labor movement, worker choice on the issue of union representation, the process of collective bargaining and the impact of collective bargaining on the management of the firm. Prerequisites: Eco 1, or Eco 11 and 12. Hyclak

335. Labor Economics (3)
The economic analysis of labor markets, with emphasis on labor supply and demand, wage and employment theory, and the economics of unionism and other labor market institutions. Prerequisites: Eco 1, or Eco 11 and 12. Thornton

336. Business and Government (3)

Analysis of government involvement in the private sector. The problems of monopoly, oligopoly, and externalities in production and consumption. Optimum responses to market failure and analysis of the performance of actual government policies. Prerequisite: Eco 105. Munley

337. Transportation and Spatial Economics (3)

The principles of transportation in theory and practice. Transport models and location theories under varying conditions of spatial separation of economic activity. Analysis and evaluation of transportation policies. Prerequisite: Eco 105 or consent of the department chairman. Pillsbury

339. International Trade (3)

The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development of the world economy. Prerequisites: Eco 1, or Eco 11 and 12. McDonald, Dearden

340. (Fin 340) International Finance (3)

Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 229. Callahan, Gunter

343. European Economic Integration (3)

Analysis of the problems of economic integration with special emphasis on the development of economic cooperation and integration in Western Europe. The methods and the problems of economic planning in the Common Market. United States trade and investments, and European economic integration. Prerequisites: Eco 1, or Eco 11 and 12. Jensen

346. Business Cycles and Forecasting (3)

A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisites: Eco 1, or Eco 11 and 12, and a course in statistics.

351. Introduction to Mathematical Economics (3)

Application of mathematical techniques to economic problems of optimization and to economic models. Prerequisites: Math 41 and 44, Eco 105 and 119. Taylor, Innes

352. Advanced Statistical Methods (3)

Advanced probability theory, probability and sampling distributions, and classical statistical inference. Index numbers, multiple regression, correlation, and analysis of variance. Spectral analysis, Box-Jenkins auto-regressive and moving average stochastic processes. Prerequisites: Eco 1, or Eco 11 and 12, and a course in statistics. Taylor

353. (Fin. 353) Public Economics and Government Finance: Federal (3)

A course dealing with the expenditures and revenues of the Federal government. Major topics include public choice theory, benefit-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisites: Eco 1 or Eco 11 and 12.

354. (Fin 354) Public Economics and Government Finance: State and Local (3)

A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisites: Eco 1 or Eco 11 and 12.

357. Econometrics (3)

Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisite: a course in statistics and a course in intermediate economic theory. Prerequisites: Eco 1, or Eco 11 and 12. King

361. Senior Seminar (3)

Intensive study and discussion of significant topics in economic policy and theory. Prerequisite: senior standing as economics major or consent of department chairman.

362. Martindale Research Seminar (1-3 hrs.)

This course prepares students to undertake research on various topics in business and/or economics. Admission to this course is limited to student associates of the Martindale Center for the Study of Private Enterprise. Consent of the instructor is required. Course may be repeated for credit up to a maximum total number of 3 hours credit.

368. Health Economics (3)

Supply and demand in the health service markets for the U.S. and Canada. Unique features of health care which interfere with competitive market allocation and pricing. Overview of insurance systems and other payment methods. Prerequisites: Eco 105 and a course in statistics. King

371. Special Topics in Economics (3)

Study in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly scheduled courses. Prerequisite: preparation in economics acceptable to the department chairman.

372. Special Topics in Economics (3)

Continuation of Eco 371.

For Graduate Students**401. Basic Statistics for Business and Economics (3)**

Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis, and analysis of variance. Computer applications. King, Thornton

408. Price Theory and Applications (3)

The role of the price mechanism in the allocation of resources. Theoretical development and empirical estimation of demand, production and cost functions. Analysis of equilibrium price-output determination in competitive and monopolistic markets. Prerequisites: Eco/Mgt 101 (or calculus) and Eco 401 (or equivalent). Munley

409. Money, Banking, and Macroeconomic Analysis (3)

The monetary process and the determination of macroeconomic variables: income, output, employment, and prices. Money and capital markets, interest rates, functions of financial intermediaries, monetary and fiscal policy, and recent macroeconomic issues. Prerequisite: Eco 408 (or concurrently). Gunter, Innes, Schwartz

411. Energy Economics (3)

The economics of energy production and consumption. Energy system modeling for forecasting and planning. Theoretical models of resource exploitation over time. Regulation of the energy industry. Prerequisites: Eco 408 and Mgt 401 or equivalents. McNamara

413. Urban Economics (3)

The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation. Pillsbury

415. Econometrics I (3)

Computer applications of standard econometric techniques using regression analysis in a single equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: a course in basic statistics. King

419. Economic History of the United States (3)

Analysis of the colonial economy, transition to industrialization, and role of trade and transportation in

America's development. A consideration of the importance of slavery to the 19th century American and other New World economies. Origin and development of banking and financial markets. Prerequisites: intermediate microeconomic theory and basic statistics. Callahan

420. Advanced Macroeconomic Analysis (3)

Macroeconomic theory and policy. Primary emphasis on theoretical models and policy implications. Prerequisite: Eco 119 or equivalent. Innes

421. Managerial Economics (3)

Application of economic analysis to business problems: price and output determination in various markets, analysis of cost and the forecasting of business conditions. Case studies. Prerequisites: Eco/Mgt 101 (or calculus) and Mgt 401 (or equivalent) and course in intermediate microeconomic theory. McNamara

432. Advanced Microeconomic Analysis (3)

A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: Eco 408 or equivalent. Dearden

433. (Fin 433) Valuation Seminar (3)

Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Beidleman, Buell

434. Government Regulation of Business (3)

Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: a course in intermediate microeconomic theory. Munley

435. Advanced Topics in Microeconomics (3)

Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisite: Eco 432 and 145 or equivalents. Dearden

436. Advanced Topics in Macroeconomics (3)

Models of employment, income, and growth in monetary economies. Policies for economic stability and growth. Prerequisite: Eco 420 or equivalent. O'Brien

437. Labor Economics (3)

The economics of labor markets and various labor market institutions with emphasis on current theoretical and empirical research. Prerequisites: Eco 408 and 401 or equivalents. Thornton

438. Labor-Management Administration (3)

A study of the U.S. system of industrial relations, including the evolution and present status of labor law; union organizing efforts; the strategy of negotiations; the substantive provisions of collective bargaining and the administration of collective agreements. Hyclak

439. History of Economic Thought (3)

Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory. Cohen, Schwartz

440. Regional Science-Metropolitan Analysis (3)

A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas. Pillsbury

443. Economics of Environmental Management (3)

The effect of environmental policies on resource allocation. Survey of the major pollution control programs currently in place in the U.S. Prerequisite: Eco 408. Munley

444. (Fin 444) Banking and Monetary Policy (3)

Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

445. International Trade Theory (3)

Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: Eco 432 or consent of the chairman. Gunter

446. International Monetary Economics (3)

Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: Eco 420 or consent of the chairman. McDonald

447. (Fin 447) Capital and Interest Theory (3)

Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance. Schwartz

449. (Fin 449) Public Finance (3)

The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

451. International Economic Development (3)

An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature. Cohen

453. Index Numbers and Time Series Analysis (3)

Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods. Taylor

454. Forecasting (3)

Methods of economic and business forecasting. Taylor

455. Econometrics II (3)

Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: Eco 415, 145 and 456 or equivalent background in statistics, calculus and matrix algebra.

456. Mathematical Economics (3)

Applications of various mathematical techniques in the formulation and development of economic concepts and theories. Prerequisite: consent of the department chairman. Taylor

457. (Fin 457) Monetary Theory (3)

The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: Eco/Fin 444 or equivalent. Innes, Callahan, Gunter

459. (Fin 459) International Financial Economics (3)

Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management. Callahan, Gunter

461. Methodology in Theory and Research (3)

Foundations of theory construction and empirical research in economics.

463. Advanced Statistics for Business and Economics (3)

An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests. Prerequisites: Math 41 and Math 44 or equivalents. Taylor

465. Industrial Organization (3)

Theoretical and empirical analysis of how the structure, organization, and behavior of firms and industries affect economic performance and economic welfare. Prerequisite: Eco 408 or equivalent. Chisholm, Deily

468. Health Economics (3)

Economic theory of health care delivery systems. Financing health care services. Case studies of specific economic/financing problems and/or international comparisons of health care delivery. Prerequisites: Eco 401 and Eco 408, or permission of the instructor. King

471. Special Topics in Economics (3)

Extended study of an approved topic not covered in scheduled courses.

472. Special Topics in Economics (3)

Continuation of Eco 471.

490. Thesis**499. Dissertation in Economics and Business**

Education, College of

Alden J. Moe, *dean*.

The College of Education is organized into two departments and eight program areas. The departments are the Department of Counseling Psychology, School Psychology, and Special Education and the Department of Leadership, Instruction, and Technology.

The department faculties and program offerings are listed below followed by descriptions of course offerings. More details on specific degree requirements and on University Graduate School regulations can be found in the section on Advanced Study and Research.

Department of Counseling Psychology, School Psychology, and Special Education

Professors. J. Gary Lutz, Ed.D. (Lehigh), *chairperson*; Raymond Bell, Ed.D. (Lehigh); Diane M. Browder, Ph.D. (Virginia); Donald T. Campbell, Ph.D. (California-Berkeley); John A. Mierzwa, Ed.D. (Harvard); Edward S. Shapiro, Ph.D. (Pittsburgh); Arnold R. Spokane, Ph.D. (Ohio State).

Associate professors. George J. DuPaul, Ph.D. (Rhode Island); William B. Stafford, Ed.D. (Indiana).

Assistant professors. Linda M. Bambara, Ed.D. (Vanderbilt); Christine L. Cole, Ph.D. (Wisconsin-Madison); April E. Metzler, Ph.D. (Florida); Tina Q. Richardson, Ph.D. (Maryland).

Adjunct faculty. Christina Le Ager, Ed.D. (Lehigh); Deborah Barlieb, Ph.D. (Penn State); Mark H. Bickard, Ph.D. (Chicago); Ian T. Birky, Ph.D. (Oklahoma State); Frank M. Datilio, Ph.D. (Temple); Diane E. Flisser, Ed.D. (Lehigh); Jeanette Gallagher, Ph.D. (Loyola); Beth R. Golden, Ph.D. (Virginia Commonwealth); Levan Lim, M.Ed. (Texas); Nancy Rovinski, Ed.D. (Columbia); Gina R. Scala, Ed.D. (Lehigh); Bruce S. Sharkin, Ph.D. (Maryland); Mervin P. Smolinsky, Ph.D. (Pittsburgh); Diane P. Toby, Ph.D. (Univ. of Pennsylvania); S. Lloyd Williams, Ph.D. (Stanford).

The department offers masters degrees and professional certification in Special Education and Social Restoration as

well as the Ed.S. degree and professional certification in Elementary and Secondary School Counseling, Counseling and Human Services, Counseling Psychology and School Psychology. An Ed.D. program is offered in Special Education and the Ph.D. is offered in Counseling Psychology, School Psychology, and Special Education. While general courses in the College are listed separately, the courses pertinent to each program are listed below.

Department of Leadership, Instruction, and Technology

Professors: Joseph P. Kender, Ed.D. (Pennsylvania), *Chairperson*; Donald E. Langlois, Ed.D. (Columbia); Robert L. Leight, Ed.D. (Lehigh); LeRoy J. Tuscher, Ph.D. (Florida State); Perry A. Zirkel, J.D. Ph.D. (Connecticut), LL.M. (Yale), *University Professor of Education and Law*.

Associate professors: Ward M. Cates, Ed.D. (Duke); Francis A. Harvey, Ed.D. (Harvard); Warren R. Heydenberk, Ed.D. (Colorado); Lourdes Diaz Soto, Ph.D. (Pennsylvania State); Sandra J. Tracy, Ph.D. (Purdue).

Assistant professors: Judith A. Bazler, Ed.D. (Montana); H. Lynn Columba, Ed.D. (Louisville); Gail G. Smith, Ed.D. (Pennsylvania State); George P. White, Ed.D. (Peabody). **Adjunct faculty:** Alfred J. Castaldi, Ed.D. (Pennsylvania); John M. Cipollini, Ph.D. (Pittsburgh); Scott C. Greenwood, Ed.D. (Lehigh); John D. McAndrew, Ed.D. (Lehigh); James E. Morrell, Ed.D. (Lehigh); Herbert Rubenstein, Ph.D. (Columbia); David R. Snyder, Ed.D. (Lehigh).

The department offers masters degrees and professional certification in Elementary and Secondary School Administration, Elementary and Secondary Education, Reading, as well as a master of science in Educational Technology. Ed.D. degree programs are offered in Educational Leadership, Educational Technology, Elementary Education, Foundations of Education and Reading. While general courses in the College are listed separately, the course offerings for each program are listed below.

Education

Educ 312. Classroom Practice (1-3)

Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussion and observations. Prerequisite: consent of the program director.

Educ 313. Intern Teaching (3-6)

Intensive practice in the application of the principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 314. Seminar in Elementary and Secondary Education (1-3)

Critical analysis and discussion of classroom instructional practices based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

Educ 320. (Psyc 320) Psychology of Language (3)

Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults.

Educ 321. The Writing Process (3)

Developmental characteristics of children's writing and relationships among writing, spelling and reading. Predictors of writing achievement, teaching strategies and activities, and evaluation schemes will be emphasized, K-12.

Educ 330. Study of the Individual (3-6)

Examinations of individual growth and development, especially the patterns found in different subcultures. Prerequisite: consent of the program director.

Educ 341. The Teacher in Social Restoration (3-6)

Functions of the teacher and the school in prevention and remediation of antisocial behavior. Field work in remedial teaching and experience in social restoration institutions. For social restoration interns only.

Educ 343. The Disadvantaged Student (3)

Philosophical analyses of disadvantage and relevant educational theories. Applications and evaluations of special methods and techniques.

Educ 388. Statistical Computing (3)

Use of one or more major statistical software packages. Principles of data coding, editing, integrity checking, and management. Emphasis on link between personal computers, mainframes, and other software. Prerequisite: Educ 408 or consent of instructor.

Educ 391,2. Workshops (1-3)

Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

Educ 394. Special Topics in Education: (with subtitle) (3)

Examination of a topic of research or professional interest in Education. Subtitle will vary. May be repeated for credit as Subtitle varies.

Educ 400. Educational Psychology (3)

An overview of learning theories, human growth and development, and the effect of selected educational practices upon the student. Attention is given to alternative strategies and processes of learning intervention.

Educ 401. Sociological Foundations of Education (3)

The American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership; its role in socialization and its responsibilities for relevance to social issues and to subcultural needs.

Educ 403. Research (3)

Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

Educ 404. Introduction to Testing and Evaluation (3)

Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

Educ 405. Comparative Education (3)

Survey of educational practices abroad from nursery to graduate education. Systems of articulation, social foundations, legal foundations, and structure in government. Nature and purposes of the schools with reference to cultural patterns. Focus upon major problems and trends.

Educ 406. Historical Foundations of Education (3)

Development of primary, secondary, and higher education; aims, curricula, methods, and systems of schooling in America from colonial time to present, in relation to social conditions.

Educ 407. Philosophical Foundations of Education (3)

Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought.

Educ 408. Introduction to Statistics (3)

Organization and description of data. Principles of statistical

inference including hypothesis testing, interval estimation, and inferential error control. Emphasis on application.

Educ 409. Analysis of Experimental Data (3)

Emphasis on analysis of variance designs including one-way, factorial, nested, and repeated measures designs. Introduction to multiple regression and the analysis of covariance. Prerequisite: Educ 408 or consent of instructor.

Educ 410. Univariate Statistical Models (3)

The univariate general linear model. Principles of expressing models and hypotheses about those models. Emphasis on similarity among the analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 409 or consent of the instructor.

Educ 411. Multivariate Statistical Models (3)

The multivariate general linear model. Principles of expressing multivariate models and hypotheses about those models. Emphasis on similarity among the multivariate analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 410 or consent of the instructor.

Educ 412. Advanced Applications of Psychometric Principles (3)

Conceptual examination of exploratory and confirmatory factor analysis, cluster analysis, latent-trait modeling, and other advanced psychometric topics. Prerequisites: Educ 409 or equivalent, SchP/CPsy 427 or SchP/SpEd 405.

Educ 413. Intern Teaching (3-6)

Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 414. Intern Teaching Seminar (3)

Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

Educ 415. Classroom Didactics (3)

Initial preparation of interns for classroom teaching. Secondary interns are trained in teaching methods in subject fields and the reading problems of secondary students. Elementary interns study teaching methods in the elementary school. Open to teaching interns only.

Educ 416. (SR 416) Quasi-Experimentation and Program Evaluation (3)

Social science research methods for non laboratory settings. Detailed examination of a dozen quasi-experimental research designs, three dozen threats to validity, possible controls, and uses in social program evaluation. Non-mathematical presentation.

Educ 417. Participation in Teaching (3)

Study, directed observation of, and initial practice in the various phases of teaching in a laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

Educ 418. Science in Elementary Education (3)

Principles of the elementary science program. Demonstrations and discussions of appropriate materials and techniques for teaching science concepts to elementary school students.

Educ 419. Mathematics in Elementary Education (3)

Mathematical skills and concepts for the elementary school program. Sets, systems of numeration, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

Educ 420. Linguistics in Education (3)

The nature of language, phonetic applications and the relationships of linguistics to instruction in the language arts.

Educ 421. Materials in Reading (3)

Provides examination and critical analysis of published and unpublished reading materials used in instruction from kindergarten through adult levels. Prerequisite: Educ 426 or consent of the program director.

Educ 422. Language Development of Children (3)

The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

Educ 423. Curriculum and Instruction in Social Studies (3)

Curriculum, content, teaching strategies, and instructional materials of the social studies field. Emphasis will be placed on organizing content, using appropriate methods, testing and evaluation, and innovations for social studies at the elementary, middle, and high school levels. Attention will be given to examining textbooks, courses of study, and teacher-made materials.

Educ 424. Developmental Reading (3)

Introductory course spanning the elementary and secondary levels. Reading methods, materials, the disadvantaged and gifted reader, procedures for individualized reading instruction.

Educ 425. Fine Arts in Elementary Education (3)

Techniques for the infusion of concepts, skills and understandings from the creative arts into the elementary school program.

Educ 426. Diagnosis and Adjustment of Reading Difficulties (3-6)

Psychology of reading related to learning difficulties; measurement and diagnosis of reading difficulties; development of informal tests; materials for corrective and/or remedial instruction. Prerequisite: Educ 424 or consent of the program director.

Educ 427. Children's Literature in Reading Instruction (3)

Role of literature in the instructional program of the elementary schools. Use of trade books for individual instruction in reading.

Educ 428. Reading in the Content Areas (3)

Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students.

Educ 429. Child Development (3)

A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

Educ 430. Advanced Topics in Reading (3)

Theory and research in historical background of reading instruction; cognitive, affective, and linguistic aspects of reading; implications for the disadvantaged and gifted reader. Field experience required. Prerequisite: Educ 424 or consent of the program director.

Educ 431. Critical Thinking in Reading (3)

An understanding of the reading/thinking process and its relationship to logic, leading to the ability to analyze, criticize and advocate ideas and to reach factual or judgmental conclusions based on inferences drawn from the printed word. Implications and methods for teaching elementary through college level students will be addressed.

Educ 432. Reading Specialists Clinic (6)

Concentrates on diagnosis of reading problems and

disabilities and the remediation of the deficits in children. Requires the graduate student to work with reading-disabled children for 125 clock hours.

Educ 433. Mathematics in Middle Level and High School Education (3)

Curricula, instructional activities, and manipulative aids applicable to mathematics courses in middle level and high schools. Teaching strategies and materials appropriate for teaching mathematics will be emphasized. Permission of the instructor.

Educ 434. Seminar in Reading Research (3)

An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

Educ 435. Adult Literacy (3)

The magnitude of illiteracy in the United States and its implications will be covered. Characteristics of the adult learner will be addressed as well as appropriate assessment strategies and instruments, methods of instruction, materials and programs. Program funding and development will be explored.

Educ 436. Practicum in Supervision of Reading Program (3)

For candidates for supervisor's certificate in reading. Organization of the instructional processes in reading programs. Participants in supervisory activities.

Educ 437. Science in Middle Level and High School Education (3)

Curricula, philosophy, methodology, strategies and safety in the teaching of middle and high school science. Emphasis on laboratory and instructional technology, at-risk and underrepresented students and current models of science education. Permission of the instructor.

Educ 438. Programs for Gifted and Talented (3)

Characteristics of gifted children; teaching gifted children; programs for the gifted in elementary and secondary schools.

Educ 441. Youth in Society (3)

Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with sibling, peers, adults, subcultures, in the context of changing institutions and values.

Educ 450. Curriculum Construction (3)

Theoretical models of curriculum design and evaluation. Scope, sequence, articulation, continuity, and balance in designs. Organizing for curriculum planning, development, implementation and change. K-12.

Educ 451. (Psyc 451) Theories of Learning (3)

In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories.

Educ 455. Philosophical and Historical Foundations of Curriculum Study (3)

Analysis of the philosophical, historical, sociological, and psychological foundations of curriculum study. Particular emphasis upon key historical figures, policy statements and major movements in the curriculum field.

Educ 456. School Curriculum (3)

Curricular innovations. Applications of curricular designs K-12. Subject matter and course design. Integration and importance of the fine arts and physical education in the curriculum.

Educ 460. Program Evaluation (3)

The historical background, theory, methodology, and current practices of program evaluation in the human services area. Emphasis will be placed on conducting evaluations of educational programs. Current research will be conducted and an examination of on-going program evaluations will be conducted.

Educ 461. Single-Subject Research Design (3)

Experimental designs for use with small N's. Topics include design theory and application, experimental validity (internal, external, statistical conclusions and construct validity) and an overview of data analysis procedures.

Educ 471. (CPsy 471) Multicultural Issues (3)

Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

Educ 473. (SR 473) Social Basis of Human Behavior (3)

Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

Educ 474. (Psyc 474) Psychological Development in Childhood (3)

Topics selected from such areas as socialization and the parent-child interaction, personality disorders in childhood, moral development and cognitive development. May be repeated for credit.

Educ 491,2. Advanced Seminars: (with subtitle) (1-6)

Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

Educ 493. Internship in: (with subtitle) (3)

Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

Educ 494. Field Work in: (with subtitle) (3)

Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans.

Educ 495. Independent Study in: (with subtitle) (1-6)

Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

Educ 496. Doctoral Research Seminar (3)

For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Educ 497. Advanced Doctoral Seminar in Curriculum and Instruction (with subtitle) (3)

Seminar on special topics such as curriculum management, integration of curriculum, middle school curriculum, etc. May be repeated for credit. For doctoral students or with the consent of the instructor.

Educational Leadership*For Graduate Students***EdL 400. Educational Administration: Theory and Practice (3)**

Development of theories of administration and applications in educational institutions. Administrative behavior in organizational settings; administrator's leadership role in decision-making, evaluation, and conflict resolution.

EdL 406. School Principals Clinic (3-6)

Simulated materials workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators.

EdL 411. Doctoral Seminar in School Administration (3)

Analysis of the theoretical, empirical, and conceptual aspects of contemporary issues in educational administration and their implications for policy formulation

and implementation in educational institutions.

Prerequisite: Official standing as a doctoral student in Educational Administration.

EdL 412. Computer Applications in School Administration (3)

Hands-on experience with computer applications useful in the administration of schools. Applications will include word processing, data base management, financial and demographic forecasting, resource allocation, graphical representation of data, and data retrieval and reporting systems useful for administrative decision making.

EdL 457. Performance Appraisal (3)

Essential elements for the evaluation of school teachers, principals and superintendents. Research-based constructs as well as practical applications. The course is intended primarily for future and practicing school administrators.

EdL 466. Supervision of Instruction (3)

Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations K-12.

EdL 467. Management Seminar for Supervisors (3)

A seminar on organization and management for first-line instructional supervisors. Covers four areas, including the legal aspects of supervision, budget development, evaluation, and organization behavior.

EdL 469. Advanced Instructional Supervision (3)

A staff development approach to supervision designed to extend the supervisor's knowledge of and skills in applying clinical techniques to instructional supervision.

EdL 470. Special Topics in Educational Leadership (1-6)

Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

EdL 472. The Principalship (3)

Major problems of organization and administration of schools, types of organization, pupil promotion, program of studies, teaching staff, pupil personnel, contract management, time allotment, plant and equipment, and community relations. Prerequisite: EdL 400.

EdL 473. Human Resources Management (3)

Overview of the effective utilization of the human resources of educational organizations. Trends in human resource planning, recruitment, selection, development, evaluation, compensation and contract administration.

EdL 474. Planning for Facility Use (3)

Focus on long-range planning with emphasis on data collection and analysis involved in closing, modifying and/or establishing alternative uses for school facilities. Simulations and field applications are provided.

EdL 476. School Financial Management (3)

Theoretical and practical foundation in financial management emphasizing the economics of education, financing and distribution of funds, and the management of funds at the school and district level.

EdL 477. Seminar in School-Community Relations (3)

Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

EdL 478. Collective Bargaining in the Schools (3)

Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education.

EdL 479. School Law (3)

Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

EdL 481. Policy and Politics in Public Education (3)

Analysis of the forces, factors, agencies, formal governmental systems and informal subsystems that influence educational policy in local districts and state and national governments.

EdL 485. The Superintendency (3)

A theoretical and historical examination of superintendents' leadership, school board/superintendent relations, and the array of duties and demands upon the superintendency.

Counseling Psychology**CPsy 427. (SchP 427) Standardized Tests and Measurements (3)**

Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests.

CPsy 430. Philosophy and Principles of Counseling (3)

Theoretical foundations, principles, and legal and ethical aspects of counseling. The organization, function, and services of a counseling program are examined. Accountability, counseling the culturally different, use of standardized tests, and other current issues are considered.

CPsy 433. Community Psychology (3)

Community agencies are examined through readings, lectures and student presentations. Field investigation of a community counseling agency. Professional ethics, legal issues, accountability and organizational structure of agencies.

CPsy 436. Career Development (3)

Examination of the career development process for children, adolescents, and adults. Study of theorists, vocational assessment process, and occupational and psychological information systems.

CPsy 439. Theory and Practice of Group Counseling (3)

Introduction to the process of group counseling and therapy. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical considerations with groups. Study of research on group processes, group therapy, and group leadership. Prerequisites: permission of the program coordinator required.

CPsy 440. Introduction to Family Counseling (3)

Research and current trends in the practice of family counseling. Overview and analysis of major theoretical approaches of family therapy.

CPsy 442. Counseling and Therapeutic Approaches (3)

Introduction to theories and techniques of counseling and therapy. Students will practice therapeutic skills through role play and sessions with clients. Audio and video recordings required. Prerequisites: CPsy 430 or CPsy 433 or permission of instructor.

CPsy 445. Elementary School Counseling and Guidance (3)

Emphasizes professional concerns of the elementary school counselor in working with teachers, parents, administrators, and other specialists. Policies, practices, and curriculum concerns, as they affect the development of the child. Prerequisite: CPsy 430.

CPsy 448. Secondary School Counseling and Guidance (3)

Establishing an effective secondary counseling and guidance program within the framework of the school setting. Policies, procedures, and curriculum concerns as they affect the student. Professional approaches to involve students, teachers, administrators, and parents in the counseling and guidance activities of the secondary school. Prerequisite: CPsy 430.

CPsy 451. Group Counseling and Group Processes (3)

Group processes as related to counseling and psychotherapy through group participation and demonstration. Prerequisites: CPsy 442 previously or concurrently; CPsy 439; permission of the program coordinator required.

CPsy 454. Biofeedback in Counseling (3)

Theory and practice in biofeedback techniques; experience in using biofeedback instruments. Special attention is paid to relaxation procedures, anxiety reduction, and behavioral medicine. Prerequisite: CPsy 442.

CPsy 457. (Psyc 473) Personality and Adjustment (3)

Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director.

CPsy 460. (Psyc 475) Theories of Psychological Counseling (3)

Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisites: admission to the Ph.D. program in counseling psychology, or permission of the counseling psychology program coordinator.

CPsy 461. Assessment of Adult Intellectual Functioning (3)

Administration and interpretation of individual tests/batteries of adult intelligence and neuropsychological functioning. Consideration of psychological and cross-cultural issues in intellectual assessment. Preparation of psychological reports. Prerequisite: CPsy 427, and permission of the instructor.

CPsy 462. Assessment of Personality (3)

Consideration of issues and methods of personality assessment, including ethical and legal issues, and cross-cultural issues. Practice in the administration of instruments used for personality assessment. Supervised experience and report writing. Prerequisites: CPsy 427, and admission to the Ph.D. program in counseling psychology.

CPsy 466. Current Issues in Counseling and Therapy (1-6)

Examination of an area of counseling or therapy that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

CPsy 470. Independent Study and Research (1-6)

Individual or small group study in the field of counseling. Approved and supervised by the major adviser. May be repeated for credit.

CPsy 471. (Educ 471) Multicultural Issues (3)

Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

CPsy 472. Human Development Across the Lifespan (3)

An examination of prevailing theories of human growth and development across the lifespan. Examination of the interactive effect of various age groups upon one another. Particular emphasis on the helping relationships.

CPsy 473. Research Seminar in Counseling (1-3)

For doctoral students in counseling psychology. Issues and methods in research design, data collection, and data analysis, criticism and evaluation of student proposals. Admission to the Ph.D. program in counseling psychology or permission of the counseling psychology program coordinator.

CPsy 474. Pre-Practicum I (3)

Beginning counseling skills are taught using audio and video recordings. Supervision is provided in small groups. Prerequisite: permission of instructor.

CPsy 475. Pre-Practicum II (3)

Counseling skills and key concepts are taught using audio and video recordings. Supervised experience in a counseling setting. Prerequisite: CPsy 474.

CPsy 476. Supervision of Counseling (1-6)

For candidates for supervisor's certificate or doctorate in counseling. Observation and supervision of counseling practicum students. Prerequisites: CPsy 480 and permission of instructor.

CPsy 478. Advanced Group Leadership (1-6)

Practicum training in group leadership in a counseling or therapeutic setting. Prerequisites: CPsy 439, CPsy 451, CPsy 480 and permission of instructor.

CPsy 480. Practicum (1-4)

Twenty hours of weekly supervised practicum training for advanced graduate students in individual, group, and family counseling and therapy. Prerequisites: CPsy 442, CPsy 451, CPsy 475, and permission of instructor. May be repeated for credit.

CPsy 483. Field Work in Counseling (3-6)

Twenty hours of weekly supervised professional practice in a school or agency setting as an extension of CPsy 480 Practicum. On-site supervision, audio and/or video recordings and case presentations required. Prerequisites: CPsy 480, and permission of the counseling psychology program coordinator.

CPsy 486. Family Counseling Clinic (3-6)

Supervised practicum training for advanced graduate students in family counseling and therapy. Techniques and methods of conducting family counseling and therapy. Prerequisites: CPsy 480 and CPsy 440.

CPsy 487. Advanced Practicum I (3)

Supervised clinical experience for entry-level doctoral students. Emphasis on intake and assessment procedures. Audio and video recording, staffing, and individual and group supervision. Prerequisite: admission to the Ph.D. program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 488. Advanced Practicum II (3)

Supervised clinical experience with emphasis on the development of intervention skills. Audio and video recording, staffing, and case presentations are required. Individual and group supervision. Prerequisite: CPsy 487. Admission to the Ph.D. program in counseling psychology and permission of the counseling psychology program coordinator.

CPsy 489. Advanced Practicum III (3)

Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings, small group supervision, and individual supervision, case presentations required. Prerequisites: CPsy 488, admission to the Ph.D. program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 491. Advanced Practicum IV (3)

Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings with emphasis on a blend of individual and group counseling, consultation, training and supervision. Case presentations, small group supervision and individual supervision are required. Prerequisites: CPsy 489 and permission of the counseling psychology program coordinator.

CPsy 498. Counseling Psychology Doctoral Internship (1)

A one year full time or two year half time supervised internship in professional psychology. Student functions as regular staff member. Regular contact with academic advisor required in addition to end of semester evaluation by the internship site and the student. Prerequisite: CPsy 491, and

permission of the Counseling Psychology program coordinator. (Repeatable for a total of 3 credits).

Educational Technology**EdT 311. Instructional Programming in BASIC (3)**

Introduction to microcomputers and their applications in educational settings. Special emphasis on a structured approach to programming in the BASIC language and on application of principles of instructional design to the development of microcomputer-based instructional materials. No prior experience with microcomputers or programming is assumed. Departmental approval required.

EdT 313. Instructional Programming in PASCAL (3)

PASCAL for microcomputers. High level, structured, procedure-oriented languages are examined. Special emphasis on use of structured programming for designing instructional software. Students electing EdT 313 are expected to complete the same course requirements as students taking CSc 11. In addition, they are required to become familiar with a microcomputer disk operating system. This is achieved through course assignments requiring the use of a microcomputer. The additional course requirements add an extra hour per week to the student workload.

EdT 315. Elementary Artificial Intelligence Applications (3)

How computers play chess, compose music, create prose, simulate psychiatrists, and make medical diagnosis (an illustration of expert systems).

EdT 331. Human Information Processing (3)

Study of the processes involved in perception, learning, problem solving and decision making. Applications of task analysis and artificial intelligence to the design of learning system.

EdT 351. Cognitive Science (3)

A synthesis of elements of artificial intelligence, psychology and linguistics; concerned with models of the acquisition, representation, storage, retrieval and application of knowledge.

EdT 404. Interactive Multimedia Programming (3)

Introduction to programming interactive multimedia applications in education and training. Emphasis given to event driven, object oriented like programming in the design and creation of applications utilizing sound, video, graphics and computer animation.

EdT 405. Hypermedia Theory and Applications (3)

Analysis of the theory of hypertext and hypermedia. Emphasis on the examination of current practices and research in hypermedia. This course is a complementary course to courses on hypermedia programming.

EdT 406. Advanced Multimedia Design and Programming (3)

Application of advanced hypermedia programming techniques utilized in the design and delivery of microcomputer-based instruction. Applications development will involve the application and design of advanced 3D animation, digital sound, and video overlay techniques. Interactive Multimedia Programming and Hypermedia Theory and Practice or consent of the instructor required.

EdT 407. Foundations of Educational Technology (3)

Examination of the effects of recent developments in communications technology, cognitive psychology, computer science, and related disciplines upon the educational process.

EdT 418. Desktop Publishing (3)

This course emphasizes the application of visual design technologies required to create and publish electronically prepared documents. The creation of high quality text and special graphics effects will be examined. Advanced

technologies related to desktop publishing such as optical character recognition, color printing theory and digital video will be included.

EdT 420. Media Production for Instructional Programming (3)

Applications in the design, production, editing, and evaluation of educational video tapes. Students will gain hands-on experience designing, filming, editing, and producing educational learning materials in a studio production center.

EdT 423. Instructional Programming in LOGO (3)

Hands-on experience with LOGO as a programming language and a philosophy of education. Study of turtle geometry procedures, recursion, words and lists, hierarchical structures, and interactive programming. Case studies of LOGO applications in various settings and with various computer systems.

EdT 425. Learning, Technology and Society (3)

A general survey of the impact of educational technology on modern society. Special attention to the use of large-scale data banks and retrieval systems, problems of privacy, impact of automation on everyday life, and effects of the new learning technologies on curriculum development and education configurations.

EdT 427. Educational Technology and Instructional Games and Simulations (3)

An examination of the motivational, technical, and instructional issues related to the design of microcomputer/video educational games and simulations. Course requirements will include designing and programming an instructional game or simulation.

EdT 433. Introduction to Instructional Design (3)

Key components in the systematic design of instruction, with an emphasis on the use of instructional design models, both behavioristic and cognitive, to create effective instruction. Actual design of instructional materials employing design models used in education and industry.

EdT 435. Interactive Learning (3)

Introduction to the utilization of interactive television, video-disc technology, CD-ROM and other high technologies for producing instructional software.

EdT 436. Advanced Programming and Applications in Logo (3)

Advanced programming in Logo, with special emphasis on interactive programs, recursion, and advanced use of lists (for example, association lists and manipulating programs as data). Analysis of current practices and issues related to Logo in education. Prerequisite: EdT 423 or equivalent.

EdT 443. Microcomputer-Aided Instruction (3)

Design and development of microcomputer-assisted instructional units. Students design, program and test microcomputer-aided instructional units as a drill, practice, tutorial, and simulation exercises.

EdT 453. Advanced Seminar in Instructional Design (3)

Advanced instructional design issues related to technology-based instruction. Design of integrated instructional environments, selection of instructional metaphors, the impact of the interface on the user, and preparation of documentation and accompanying materials with emphasis on design of interactive multimedia instructional environments. Prerequisite: EdT 433 or consent of instructor.

EdT 471. Evaluation of Technology-Based Instructional Systems (3)

Examination of current issues and practices related to the design and evaluation of instructional system with special consideration to the delivery and management of instruction utilizing educational technology. A case study approach will be used to study both Instructional Systems

and the evaluation of individual learning in technology-based curricula.

EdT 477. Research Topics in Educational Technology (3)

Examination of current issues and practices related to the field of educational technology. Topics will vary (e.g., The Role of Educational Technology in Teaching Persons with Special Needs; The Role of Educational Technology in Teaching Preschool/Nursery School Children; Educational Implications of Sound and Graphics. May be repeated for credit as topic varies.

School Psychology

SchP 402. (SpEd 402, Psyc 402) Applied Behavior Analysis (3)

Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SchP 404. Historical and Contemporary Issues in School Psychology (3)

History of Psychology, Education, and School Psychology. Roles and function of school psychologist; legal and ethical aspects of school psychology.

SchP 412. Consultation Procedures (2)

Observational methodology utilized in consultation; rationale, theory and methods of consultation; individual, group and parent consulting. Study of research on the consultation process. Students must also register for 1 credit of SchP 431.

SchP 413. Advanced Research Methodology Seminar-I (1)

First of two semester courses covering advanced topics in research design, methodology, and analysis. Prerequisite: admission to doctoral program.

SchP 414. Advanced Research Methodology Seminar-II (1)

Continuation of SchP 413. Prerequisite: admission to doctoral program and SchP 413.

SchP 422. Assessment of Intelligence (3)

Administration and interpretation of individual tests of intelligence used in school evaluation and preparation of psychological reports. Prerequisite: permission of instructor.

SchP 423. Behavioral Assessment (3)

Techniques of behavioral assessment including, direct observation, interviews, checklists, rating scales, self-monitoring and role-play tests. Prerequisite: permission of instructor.

SchP 425. Assessment and Intervention in Educational Consultation (3)

Collection and use of data in designing classroom interventions. Curriculum based assessment, direct behavioral assessment, and structured interviews, and the interrelationship with diagnoses are emphasized within the behavioral consultation model. Utilization of data from actual case studies. Prerequisites: SchP 402, 423.

SchP 426. Advanced Child Behavior Therapy (3)

Techniques of child behavior therapy applied in classrooms and clinical settings. Particular emphasis on self-control procedures, such as social skills training, self-instruction training, and cognitive behavior therapy. Course covers both the theoretical and practical components of procedures. Prerequisite: SchP 402.

SchP 427. (CPsy 427) Standardized Tests and Measurements (3)

Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests.

SchP 429. Special Topics in School Psychology (with subtitle) (1-3)

SchP 431. Practicum in Consultation Procedures (1-3)

Supervised experience in conducting school-based consultations. Co-requisite, SchP 412.

SchP 432. Practicum in Assessment of Intelligence (1-3)

Supervised experience in the administration and interpretation of intelligence tests. Co-requisite, SchP 422.

SchP 433. Practicum in Behavioral Assessment (1-3)

Supervised experience in conducting behavioral assessments in school settings. Co-requisite, SchP 423.

SchP 434. (SpEd 434) Applied Research Practicum (1-3)

Designing and conducting research projects in applied settings.

SchP 435. Practicum in Assessment & Intervention in Educational Consultation (1-3)

Supervised experience in conducting curriculum-based assessments and designing intervention strategies for educational problems. Co-requisite, SchP 425.

SchP 436. Practicum in Interventions for Students with Behavior Disorders (1-3)

Supervised experience in designing and implementing interventions in classrooms for students with behavior disorders. Permission of instructor required.

SchP 437. Advanced Child Psychopathology (3)

Advanced training in the definition, classification, etiology, long-term outcome, and treatment of children and adolescents with various psychopathological disorders. Emphasis is placed upon the assessment and treatment of child and adolescent psychopathology in school settings. Prerequisites: Admission to doctoral program or by permission of instructor.

SchP 442. Doctoral Practicum in School Psychology (1-6)

Field-based experience in providing psychological services in school and/or clinical settings. Prerequisite: admission to doctoral program. May be repeated for credit.

SchP 443. Certification Internship (1-6)

Full-time experience in clinical/educational settings. Student must complete a minimum of 1,200 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SchP 444. Doctoral Internship (1-6)

Full-time experience in clinical/educational settings. Student must complete a minimum of 1,500 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SchP 496. Doctoral Seminar in School Psychology (with subtitle) (3)

Selected topics in school psychology (titles will vary) including professional issues, assessment and intervention in school settings, and supervision of school psychology services. May be repeated for credit. Prerequisite: admission to doctoral program.

Special Education**SpEd 322. Integration (3)**

Theory and application of the basic concepts on integration. Emphasis on educating students with special needs in regular school and classroom environments.

SpEd 323. Introduction to Mild Disabilities (3)

An intensive introduction to direct instruction, behavioral interventions, social skills training, curriculum based assessment, IEPs, classroom structure for those who need emotional and learning support (e.g., learning disabilities, serious emotional disturbances and mild mental retardation).

SpEd 324. Introduction to Severe Disabilities (3)

An intensive introduction to a life skills approach to curriculum, including systematic instruction, data based decisions, community based instruction, behavior management, integration and IEPs or IHPs for students who need a life skills approach (e.g., autism, severe/profound mental retardation, cerebral palsy, multihandicaps).

SpEd 330. Special Topics in Special Education: (with subtitle) (1-3)

Current issues in the education of individuals with special needs. Titles vary. May be repeated for credit as title varies.

SpEd 331. (Psyc 352) Emotional and Behavioral Disorders of Children (3)

Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SpEd 332. Education of Individuals with Special Needs (3)

Legal, educational, and social issues related to the special education of people with mental retardation, physical handicaps, emotional/behavior disorders, learning disabilities, visual and hearing impairments, health impairments and those who are intellectually gifted.

SpEd 333. Physical Handicaps and Developmental Disabilities (3)

Definition, classification, etiology, treatment and historical perspectives of individuals with mental retardation, autism, cerebral palsy, and other severe disabilities (e.g., deaf/blind). Remediation of movement difficulties, physical and occupational therapy interventions.

SpEd 339. Learning Disabilities (3)

Definition, classification, etiology, treatment, and historical perspective of individuals with learning disabilities.

SpEd 402. (SchP 402, Psyc 402) Applied Behavior Analysis (3)

Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SpEd 405. Assessment of Individuals with Mild Disabilities (3)

Educational assessment procedures used with individuals with special needs. Understanding and applying information from formal education assessment and interviews. Utilization of curriculum based assessment.

SpEd 417. Language and Social Skills (3)

Empirically based strategies to teach skills in nonvocal communication, early language, conversational skills, grammar and other communication skills to individuals with mild or severe disabilities.

SpEd 418. Teaching Individuals with Severe Disabilities (3)

Curriculum and methods for life skills instruction—self care, daily living, community based instruction, communication, social integration, vocational training, functional academics.

SpEd 419. Teaching Individuals with Mild Disabilities (3)

Emphasis on effective teaching techniques for academic and social skills. Emphasis on curriculum development and instructional strategies in language arts, math, and other academic content areas.

SpEd 420. Intern Teaching: Certification (3)

Competency based practice in application of procedures for teaching a broad spectrum of individuals with special needs in preparation for Level I Certification as a Teacher of the Mentally or Physically Handicapped. Prerequisite: consent of program coordinator one semester before registering for this course.

SpEd 424. Assessment of Individuals with Severe Disabilities (3)

Curriculum based assessment and program development for individuals whose disabilities preclude traditional academic or psychological assessment. Emphasis on life skills assessment.

SpEd 425. Specialization Internship (3)

Competency based practice to develop specific expertise in Behavior Disorders, Severe Disabilities, Consulting Teacher or Early-childhood. May be repeated for credit in more than one specialty. Prerequisite: consent of program coordinator one semester before registering.

SpEd 428. Advanced Behavior Management for Individuals with Severe Disabilities (3)

This course will develop skills in long-term remediation of problem behaviors characteristic of persons with severe disabilities through functional assessments, positive procedures, and lifestyle interventions.

SpEd 429. Professional Seminar (3)

Master's seminar on current issues in the area of special education and research design. Prerequisite is 18 graduate credits in Special Education.

SpEd 430. Advanced Seminar in Special Education (3)

Advanced issues relating to the field of special education. Titles will vary.

SpEd 432. Supervision of Special Education (3)

Advanced knowledge of teaching research with individuals with special needs. Teacher supervision models.

SpEd 434. (SchP 434) Applied Research Practicum (1-3)

Designing and conducting research projects in applied settings.

SpEd 435. Internship: Supervision of Special Education (3)

Advanced students receive competency based practice in staff supervision in preparation for certification as a Supervisor of Special Education. Prerequisite: consent of program coordinator one semester before registering for the course.

SpEd 490. Doctoral Seminar in Special Education (3)

Advanced knowledge of issues and research in the education of individuals with special needs. Topics will vary. May be repeated for credit. Prerequisite: admitted for doctoral studies.

Educational Technology

See listings under Education.

Electrical Engineering and Computer Science

Professors. Alastair D. McAulay, Ph.D. (Carnegie Mellon), *chairperson and Chandler-Weaver professor*; Donald J. Hillman, Ph.D. (Cambridge, England), *head of computer science division*; Robert F. Barnes, Ph.D. (Berkeley); D. Richard Decker, Ph.D. (Lehigh); Nikolai Eberhardt, Ph.D. (Munich, Germany); Bruce D. Fritchman, Ph.D. (Lehigh), *assistant vice president for computing and communication services*; Samuel L. Gulden, M.A. (Princeton); Frank H. Hielscher, Ph.D. (Illinois); Carl S. Holzinger, Ph.D. (Lehigh); James C. M. Hwang, Ph.D. (Cornell); Ralph J. Jaccodine, Ph.D. (Notre Dame); *Sherman Fairchild professor in solid state materials*; Arthur I. Larky, Ph.D. (Stanford); Edwin J. Kay, Ph.D. (Lehigh); Roger N. Nagel, Ph.D. (Maryland), *Harvey E. Wagner, professor of manufacturing systems engineering*; William

E. Schiesser, Ph.D. (Princeton); R.L. McCann, *professor of engineering and computer science*; Kenneth K. Tzeng, Ph.D. (Illinois); Eric D. Thompson, Ph.D. (M.I.T.); Marvin H. White, Ph.D. (Ohio State), *Sherman Fairchild professor of electrical engineering*.

Associate professors. Donald L. Tallhelm, M.S. (Lehigh), *associate chairperson, head of electrical engineering division*; Glenn D. Blank, Ph.D. (Wisconsin-Madison); Dragana Brzakovic, Ph.D. (Florida); Demetrios Christodoulides, Ph.D. (Johns Hopkins); Douglas R. Frey, Ph.D. (Lehigh); Miltiadis Hatalis, Ph.D. (Carnegie Mellon); Weiping Li, Ph.D. (Stanford); Karl H. Norian, Ph.D. (Imperial College, London); Peggy T. Ota, Ph.D. (Pennsylvania), *vice provost for academic administration*; Meghanad D. Wagh, Ph.D. (I.I.T., Bombay).

Assistant professors. Hassan Barada, Ph.D. (Louisiana State); Rick S. Blum, Ph.D. (Pennsylvania); Adair Dingle (Texas-Dallas); Madalene Spezialetti, Ph.D. (Pittsburgh).

Adjunct lecturers. Charles T. Adomshick, M.S. (Rutgers); Stephen G. Corbesero, M.S. (Lehigh).

Systems Manager. Stephen G. Corbesero, M.S. (Lehigh).

Emeritus professors. John J. Karakash, Eng.D. (Hon.) (Lehigh); Walter E. Dahlke, Ph.D. (Jena, Germany); Daniel Leenov, Ph.D. (Chicago); John J. O'Connor, Ph.D. (Columbia); Gerhard Rayna, Ph.D. (Princeton); Lawrence J. Varnerin, Ph.D. (M.I.T.); Donald R. Young, Ph.D. (M.I.T.).

The department of electrical engineering and computer science (EECS) offers undergraduate and graduate programs of study along with supporting research for students interested in the fields of electrical engineering, computer engineering, and computer science. Lehigh University offers a bachelor of science degree from the College of Engineering and Applied Science in electrical engineering, computer engineering, and computer science, and it offers the bachelor of science and bachelor of arts degree with a major in computer science from the College of Arts and Science. A minor in computer science is available except for students in the College of Engineering and Applied Science.

Graduate study leads to the degrees master of science, master of engineering, and doctor of philosophy in electrical engineering, the master of science in computer engineering, and to the degrees master of science and doctor of philosophy in computer science.

While each of the programs has its unique attributes, Lehigh's programs exploit the growing interrelationship among electrical engineering, computer engineering, and computer science. For example, a new computer system which may encompass fundamental algorithmic development, innovative architecture and logic design, and very large scale integrated circuit design and fabrication requires the expertise of individuals knowledgeable across the spectrum. Robotics experts similarly require a broad knowledge spectrum.

The undergraduate programs emphasize the fundamental aspects of their respective areas. Electives permit the student to tailor his program according to his interests and goals, whether they be in preparation for graduate study or entry into industry. Students are free to select courses offered by other departments and are encouraged to do so when appropriate. In this way they can prepare themselves for activities which straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design and/or research project.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their specialties. The thesis is regarded as an essential and important ingredient of these programs. Each graduate student develops a program of study in consultation with his or her graduate advisor.

Key research thrust areas in the department include:

1. Artificial Intelligence, particularly as applied to manufacturing, natural language understanding, parallel and distributed processing.

2. Error-control coding, signal processing, data communication and networking.

3. Silicon and gallium arsenide semiconductor electronics, optoelectronics.

Graduate research is encouraged in these and other areas.

The department maintains a number of laboratories in support of its curricular programs. These laboratories include the electronics circuits laboratory, the microcomputer laboratory, the electromechanics laboratory, the digital signal processing laboratory, the parallel computing laboratory, and the digital systems laboratory as dedicated undergraduate laboratories. The department has research laboratories in artificial intelligence, computer architectures, cryogenic circuits; design and computing systems; electron device physics; microelectronics fabrication; microwave measurements; microwave monolithic circuits; robotics; and a VLSI measurements laboratory. These laboratories are described more completely in the departmental graduate brochure. These laboratories, among others, are available for undergraduate projects.

Computers and computer usage are an essential part of the student's environment. In addition to facilities available to the university community as a whole, the EECS department has state-of-the-art Unix and non-Unix based minicomputers, special and general purpose workstations, and microcomputers in addition to direct access to the machines in the Lehigh University Computer Center (LUCC). The primary departmental computer system consists of two AT&T 3B15 minicomputers running the Unix System V operating system, with dial-in and dial-out capabilities, over 2 Gigabytes of on-line storage, high speed magnetic tape drives, extensive ethernet access. In addition to the central facilities, other department computer resources include Intel, Sun, Tektronix, and Valid workstations and DEC and HP minicomputers and a 64-node transputer used for instruction and research. There are over 60 Intel and PC-Compatible microcomputers available for hardware and software projects at all levels of the curriculum. Peripherals available to all students and faculty include a variety of printers (laser, postscript, and letter quality), plotters (pen and electrostatic), and text and graphics terminals. Communications among the departmental computer systems is provided by the campus medium-speed serial network, Unix UUCP communication links to several local and distant academic and commercial facilities, a local area network on standard 10 M bit ethernet which is in turn connected to the campus high-speed backbone network. Using these communication lines, the departmental facilities are connected to the National Science Foundation Network (NSF-Net), the Pennsylvania Research and Education Network (PREPNET), Usenet, and BITNET. Students are not required to have a personal microcomputer but some find such a tool an asset.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefixes CSc for computer science and ECE for electrical and computer engineering. The student is urged to search in both listings for courses appropriate to his career goal.

Undergraduate Programs

Bachelor of Science in Electrical Engineering

The required courses for this degree contain the fundamentals of linear circuits, systems and control theory, electronic circuits, signal theory, physical electronics, electromagnetic theory, energy conversion, digital systems, and computing techniques. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 133 credit hours. The recommended sequence of courses follows:

freshman year (see page 34)

sophomore year, first semester (17 credit hours)
Phys 21, 22 Introductory Physics II and Laboratory II (5)
Math 23 Analytic Geometry and Calculus III (4)
ECE 81 Principles of Electrical Engineering (4)
ECE 33 Introduction to Computer Engineering (4)

sophomore year, second semester (16 credit hours)
ECE 108 Signals and Systems (4)
Math 205 Linear Methods (3)
Eco 11 or 12 Economics (3)
HSS elective (3)
approved elective* (3)

junior year, first semester (17 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
ECE 125 Circuits and Systems (3)
Math 208 Complex Variables (3)
HSS elective (3)
free elective (3)

junior year, second semester (17 credit hours)
ECE 126 Fundamentals of Semiconductor Devices (3)
ECE 136 Electromechanics (3)
ECE 138 Digital Systems Laboratory (2)
ECE 202 Introduction to Electromagnetics (3)
Math 231 Probability and Statistics (3)
free elective (3)

senior year, first semester (18 credit hours)
ECE 111 Proseminar (1)
ECE 251 Senior Project I (2)
ECE 203 Introduction to Electromagnetic Waves (3)
HSS elective (3)
approved electives* (6)
free elective (3)

senior year, second semester (18 credit hours)
approved electives* (12)
HSS elective (3)
free elective (3)

*Approved electives are subjects predominantly in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. Students must choose at least one elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one elective in physics, chemistry or biology. For students interested in solid-state electronics, quantum mechanics is recommended.

Bachelor of Science in Computer Engineering

The required courses for this degree contain the fundamentals of electronic circuits, signal theory, logic design, computer architecture, structured programming, data structures, software engineering, discrete mathematics, and numerical analysis. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 134 credit hours. The recommended sequence of courses follows:

freshman year (see page 34)

sophomore year, first semester (17 credit hours)
Phys 21, 22 Introductory Physics II and Laboratory II (5)

Math 23	Analytic Geometry and Calculus III (4)
ECE 81	Introduction to Electrical Engineering (4)
ECE 33	Introduction to Computer Engineering (4)

sophomore year, second semester (17 credit hours)	
CSc 17	Structured Programming and Data Structures (4)
ECE 108	Signals and Systems (4)
CSc 261	Discrete Structures (3)
Math 205	Linear Methods (3)
	HSS elective (3)

junior year, first semester (17 credit hours)	
ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
CSc 262	Programming Languages (3)
Math 231	Probability and Statistics (3) or
Math 309	Theory of Probability (3)
	elective* (3)
	free elective (3)

junior year, second semester (17 credit hours)	
ECE 116	Software Engineering (3)
ECE 138	Digital Systems Laboratory (2)
ECE 201	Computer Architecture (3)
Eco 11 or 12	Micro- or Macroeconomics (3)
	free elective (3)
	HSS elective (3)

senior year, first semester (18 credit hours)	
ECE 111	Proseminar (1)
ECE 251	Senior Project I (2)
ECE 319	Digital System Design (3)
CSc 303	Operating System Design (3)
	HSS elective (3)
	approved elective* (3)
	free elective (3)

senior year, second semester (18 credit hours)	
	approved electives* (12)
	HS elective (3)
	free elective (3)

*Approved electives are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.

Bachelor of Science in Computer Science

Two degree programs are available to students through either the College of Arts and Science or the College of Engineering and Applied Science. The program offered by the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The two programs are identical in the fundamental requirements in mathematics and computer science, and the programs are appropriate for entry into management or industrial positions and for continued graduate study. The programs differ in that the students must fulfill the distribution requirements of the respective college. The result of this difference is that the Arts and Science program requires 124 credit hours whereas the College of Engineering and Applied Science program requires 134 credit hours. Students with interests in management, finance, data processing, and information handling may find the Arts and Science College program more appropriate and students with interests in engineering and science applications may find the Engineering and Applied Science College program more appropriate.

The required courses for the degrees contain the fundamentals of discrete mathematics, structured programming, algorithms, computer architectures, compiler design, operating systems, and programming

languages. A strong foundation in mathematics is required. The recommended sequence of courses is as follows:

College of Arts and Science

freshman year, first semester (16 credit hours)	
Engl 1	Composition and Literature (3)
Math 21	Analytic Geometry and Calculus I (4)
CSc 11	Introduction to Structured Programming (3)*
	distribution (6)

freshman year, second semester (16 credit hours)	
Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Math 22	Analytic Geometry and Calculus II (4)
CSc 15	Data Structures (3)*
	distribution (6)

sophomore year, first semester (17 credit hours)	
Math 23	Analytic Geometry and Calculus III (4)
ECE 33	Introduction to Computer Engineering (4)
	distribution (9)

sophomore year, second semester (15 credit hours)	
Math 205	Linear Methods (3)
ECE 116	Software Engineering (3)
CSc 109	Systems Programming (3)
	approved electives** (3)
	distribution (3)

junior year, first semester (15 credit hours)	
Math 231	Probability and Statistics (3) or
Math 309	Theory of Probability (3)
CSc 209	Assembly Language Programming (3)
CSc 261	Discrete Structures (3)
	approved elective** (6)

junior year, second semester (15 credit hours)	
CSc 252	Computer and Society (3)
CSc 262	Programming Languages (3)
CSc 340	Design and Analysis of Algorithms (3)
ECE 201	Computer Architecture (3)
	approved electives** (3)

senior year, first semester (15 credit hours)	
Math 230	Numerical Methods (3) or
Engr 250	Computer Modeling of Scientific & Engineering Systems (3)
CSc 303	Operating System Design (3)
CSc 318	Automata & Formal Grammars (3)
	approved electives** (3)
	distribution (3)

senior year, second semester (15 credit hours)	
CSc 302	Compiler Design (3)
	approved electives** (9)
	distribution (3)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a 3 credit hour approved elective may be substituted for CSc 11 and CSc 15.

**Approved electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student. The approved elective choices must include: a two semester sequence of laboratory science courses acceptable for majors in the field of the courses selected.

College of Engineering and Applied Science

freshman year (see page 34)

sophomore year, first semester (17 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
CSc 17	Structured Programming and Data Structures (4)
ECE 33	Introduction to Computer Engineering (4)

sophomore year, second semester (16 credit hours)

Math 205	Linear Methods (3)
ECE 81	Principles of Electrical Engineering (4)
ECE 116	Software Engineering (3)
CSc 109	Systems Programming (3)
Eco 11 or 12	Economics (3)

junior year, first semester (18 credit hours)

Math 231	Probability and Statistics (3) or
Math 309	Theory of Probability (3)
CSc 209	Assembly Language Programming (3)
CSc 261	Discrete Structures (3)
	HSS elective (3)
	free elective (3)
	approved electives** (3)

junior year, second semester (18 credit hours)

ECE 201	Computer Architecture (3)
CSc 252	Computers and Society (3)
CSc 262	Programming Languages (3)
CSc 340	Design and Analysis of Algorithms (3)
	HSS elective (3)
	approved elective** (3)

senior year, first semester (17 credit hours)

Math 230	Numerical Methods (3) or
Engr 250	Computer Modeling of Scientific and Engineering Systems (3)
ECE 251	Senior Project I (2)
CSc 303	Operating System Design (3)
CSc 318	Automatic & Formal Grammars (3)
	HSS elective (3)
	free elective (3)

senior year, second semester (18 credit hours)

CSc 302	Compiler Design (3)
ECE 316	Microcomputer System Design (3)
	HSS elective (6)
	approved elective** (6)

**Approved electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student.

Bachelor of Arts in Computer Science

This program of 121 credit hours is for students who desire a strong liberal arts program with a concentration in computer science. The program contains the fundamentals of computer science which include discrete mathematics, structured programming, data structures, programming languages, computer organization, compiler design, and operating systems. The recommended course sequence is as follows:

freshman year, first semester (16 credit hours)

Engl 1	Composition and Literature (3)
Math 21	Analytic Geometry and Calculus I (4)
CSc 11	Introduction to Structured Programming (3) *
	distribution (6)

freshman year, second semester (16 credit hours)

Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Math 22	Analytic Geometry and Calculus II (4)

CSc 15	Data Structures (3) *
	distribution (6)

sophomore year, first semester (16 credit hours)

CSc 261	Discrete Structures (3) or
Math 243	Algebra (3)
ECE 33	Introduction to Computer Engineering (4)
	distribution (9)

sophomore year, second semester (15 credit hours)

Math 43	BMSS Linear Algebra (3)
ECE 201	Computer Architecture (3)
	distribution (6)
CSc 109	Systems Programming (3)

junior year, first semester (15 credit hours)

CSc 262	Programming Languages (3)
	distribution (6)
	free electives (3)
CSc 209	Advanced Programming (3)

junior year, second semester (15 credit hours)

	distribution (6)
	free electives (9)

senior year, first semester (15 credit hours)

CSc 303	Operating System Design (3)
	distribution (3)
	free electives (6)
CSc 318	Automata and Formal Grammars (3)

senior year, second semester (13 credit hours)

	distribution (3)
	free electives (7)
CSc 302	Compiler Design (3)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a 3 credit hour approved elective may replace CSc 11 and CSc 15.

Minor in Computer Science

The minor in computer science provides a concentration which includes discrete mathematics, structured programming concepts, programming languages, and computer organization, essential elements of computer science. This minor is not available to students of the College of Engineering and Applied Science. The minor is as follows:

Math 21	Analytic Geometry and Calculus I (4)
CSc 261	Discrete Structures (3)
CSc 11	Introduction to Structured Programming (3) *
CSc 15	Data Structures (3) *
ECE 33	Introduction to Computer Engineering (4)
CSc 241	Data Base Systems (3) or
CSc 262	Programming Languages (3)

(20 credit hours)

*With approval, CSc 17, Structured Programming and Data Structures (4), can be substituted for CSc 11 and CSc 15 for an 18 credit hour minor.

Graduate Programs

Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in electrical or computer engineering, computer or information science, mathematics, or the physical sciences. Research is an essential part of the graduate program. Major research areas include:

Compound Semiconductor Microwave & Quantum Electronics

Microwave gallium arsenide monolithic integrated circuits, heterojunction device physics and materials. Ultra-high speed phenomena, modelling, packaging subsystem design. Sub-millimeter wave devices, cryogenic noise and magnetotransconductance investigations. Photonic devices, interactions and transmission. Tunnelling microscopy.

Microelectronics—Devices, Integrated Circuits, VLSI Design

Silicon integrated circuit technology, processing, fabrication and testing. CMOS, semiconductor device physics, small geometry VLSI, Josephson junction devices. VLSI logic design and verification, computer-aided (CAD), VLSI chip architecture. Non-linear circuit design.

Information and Computer Engineering

Networking and distributed computing; architecture, protocol specification and verification, loading, routing and allocation, distributed processing, error control, security and protection; real-time processing; pipelining and scheduling, signal processing algorithms, VLSI architectures, speech compression and recognition, concurrent processing; fault tolerant computing; hardware/software redundancy, coding theory, verification and testing.

Artificial Intelligence—Expert Systems

Expert systems; knowledge-based systems in design, electronics packaging, manufacturing, and construction; intelligent robotics; autonomous vehicles; natural language processing; AI programming languages; learning systems and mechanisms; data models and object-oriented systems; user interfaces; decision-support systems; integration of symbolic and computational processing modes; database interfaces; CAD/CAM/CAE/CIM problems; cognitive science.

The Master of Science degree requires the completion of 30 credit hours of work which may include a six credit hour thesis for the E.E. and CompE. degrees and a three credit hour thesis for the C.S. degree. Special topics courses are restricted to six credit hours, and the C.S. degree requires CSc 302, Compiler Design, CSc 411, Advanced Programming Techniques, and CSc 403, Theory of Operating Systems. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the graduate school rules. An oral presentation of the project is required.

The Ph.D. degree in Electrical Engineering and the Ph.D. degree in Computer Science require the completion of 42 credit hours of work (including the dissertation) beyond the master's degree (48 hours if the master's degree is non-Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

Additional graduate program information may be obtained from the department's graduate coordinator.

Departmental Courses

Courses are listed under the prefixes CSc and ECE. Generally, electrical engineering courses carry the ECE prefix and computer science courses carry the CSc prefix. Computer Engineering courses are likely to be found under either prefix. The reader is urged to consult both listings.

Computer Science (CSc)**For Undergraduate Students****CSc 11. Introduction to Structured Programming (3)**

Algorithmic design and implementation in high-level, block-structured, procedure-oriented languages. No prior computing experience required.

CSc 15. Data Structures (3)

Continuation of CSc 11. Data structures using pointer variables. Prerequisite: CSc 11.

CSc 17. Structured Programming and Data Structures (4)

Algorithmic design and implementation in high level, block-structured, procedure-oriented languages. Recursion, lexical programs, pointers, data structures, and their applications. Previous experience with programming required. NOTE: CSc 17 constitutes an accelerated course for students with some programming experience, which can be used as a prerequisite in place of CSc 11 and 15. Students may not receive credit for either CSc 11 & 15 or 17.

CSc 109. Systems Programming (3)

Advanced data structures: hash tables, B-trees, disk files. Design of assemblers, macro-processors, loaders, interpreters, translators, communication protocols. Use of a high-level language to implement sample systems. Prerequisites: CSc 17 or CSc 15, and ECE 33.

CSc 190. Special Topics (1-3)

Supervised reading and research. Prerequisite: consent of the division head.

CSc 209. Assembly Language Programming (3)

Design and development of assembly language programs for computer systems. Interactive input-output, handling interrupts, system architecture, hardware-software tradeoffs. Evaluation of program efficiency. Prerequisite: CSc 109.

CSc 230. Elementary Artificial Intelligence Applications (3)

Fundamentals of analytic expert systems; computer chess; computer composition of music; computer simulation of a psychiatrist (ELIZA); fundamentals of computer understanding of natural language (ordinary English) questions to databases.

CSc 241. Data Base Systems (3) spring

Data base concepts in terms of formal logic. Knowledge representation and deduction. Data base integrity. Query languages. Prerequisite: CSc 11 or approval of the division head.

CSc 252. Computers and Society (3)

A general nontechnical survey of the impact of computers on modern society. Special attention is given to the use of large-scale data banks and retrieval systems, the problems of privacy and file security, and the impact of automation on everyday life.

CSc 261. (Math 261) Discrete Structures (3)

Topics in discrete structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Various applications. Prerequisites: Math 21 and either CSc 11 or Engr 1.

CSc 262. Programming Languages (3) fall and spring

Use, structure and implementation of several programming languages. Prerequisite: CSc 15 or 17.

CSc 271. Programming in C and the Unix Environment (3)

C language syntax and structure. C programming techniques. Emphasis on structured design for medium to large programs. Unix operating system fundamentals. Unix utilities for program development, text processing, and

communications. Prerequisites: ECE 33 and either CSc 17 or CSc 15.

CSc 302. Compiler Design (3) spring

Principles of artificial language description and design. Sentence parsing techniques, including operator-precedence, bounded-context, and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisites: CSc 109 and CSc 318.

CSc 303. Operating System Design (3) fall

Assemblers, executive systems, multiprogramming, time-sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: CSc 109 and ECE 201.

CSc 313. Computer Graphics (3)

General principles; algorithms; display devices and organization; methods of interaction; design of visual interactive systems. Prerequisite: CSc 109.

CSc 318. Automata and Formal Grammars (3)

Formal languages, finite automata, context-free grammars, Turing machines, complexity theory, undecidability. Prerequisite: CSc 261.

CSc 327. Artificial Intelligence Applications (3)

Expert systems; analytic, constructive. Natural language (ordinary English) understanding by computer. Emphasis on systems successful in practical use or experimentally. Problems and possibilities.

CSc 330. Advanced Software Engineering Tools (3)

CASE tools; portability and reusability of software; experimental methods in software engineering; automatic programming. Prerequisite: ECE 116.

CSc 340. (Math 340) Design and Analysis of Algorithms (3)

Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching, fast Fourier transform. Minimum time and space requirements are established, leading to the notion of abstract complexity measures and the intrinsic complexity of algorithms and problems, in terms of asymptotic behavior. The question of the correctness of algorithms is also treated. Prerequisite: CSc 15 or Math 23 or consent of the division head.

CSc 365. Natural Language Understanding (3)

Design of natural language systems. Survey and implementation of current linguistic and artificial intelligence techniques for morphology, syntax, semantics and discourse. Consideration of interface with nonlinguistic applications, such as databases, robotics. Prerequisite: CSc 262 or consent of instructor.

CSc 368 Artificial Intelligence Programming (3) spring

The use of LISP and related languages to simulate intelligence on computers. Prerequisite: CSc 262 or approval of the division head.

CSc 375 Hardware & Software Topics in Parallel Computing (3)

Introduction to parallel computing, covering both hardware and software topics such as interconnection networks, SIMD, MIMD, and hybrid parallel architectures, parallel languages, parallelizing compiler techniques and operating systems for parallel computers. Prerequisite: ECE 201 and CSc 303 previously or concurrently, or consent of the instructor.

CSc 376 Parallel Algorithms (3)

Parallel algorithms for searching, sorting, matrix processing, network optimization, and selected graph problems. Implementation and efficiency measures of parallel algorithms also considered. Prerequisite: CSc 375 or CSc 340 or consent of instructor.

CSc 390 Special Topics (1-3) offered as required

An opportunity for advanced work through supervised reading and research. Prerequisite: consent of the division head. May be repeated for credit.

For Graduate Students

CSc 403 Theory of Operating Systems (3)

Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multi-programming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: CSc 303 or equivalent.

CSc 409. Theory of Automata and Formal Grammars (3)

Finite automata. Pushdown automata. Relationship to definition and parsing of formal grammars. Prerequisite: CSc 318.

CSc 411. Advanced Programming Techniques (3) spring

Deeper study of structured programming, data structures, back-tracking, recursion. Applications of basic concepts of automata theory and formal language theory. Fundamental principles of 'large program' design. Several major programming assignments using Pascal. Prerequisite: CSc 15 or 17 or consent of the division head. Gulden

CSc 412. Object Oriented Programming

Objects, messages, classes and inheritance; the model-view-controller paradigm. Prototyping the user interface. Kay

CSc 413. Robotics and Intelligent Machines (3)

Software aspects of robot and intelligent machine controls. Fundamental control issues through language and artificial intelligence implementations.

CSc 414. Expert Systems (3)

The design and development of knowledge-based expert systems. Rule-based protocols. Knowledge engineering. Programming application. Prerequisite: CSc 368.

CSc 415. Database Topics (3)

Design issues in integrated database systems. Database entities and their relationships. Prerequisite: CSc 241 or equivalent.

CSc 416. Advanced Issues in Knowledge-based Systems (3)

Advanced techniques and current applications of knowledge-based systems. Emphasis on knowledge engineering techniques through the development of a substantial system. Prerequisite: CSc 414. Hillman and Blank

CSc 417. Topics in Information Retrieval (3)

Selected topics in the design of advanced retrieval systems. Prerequisite: CSc 241 or equivalent.

CSc 418. Uncertainty in Knowledge Based Systems (3)

Basic problems and possibilities for probable inference by expert systems are discussed. In this light, Bayesian inference, certainty factors, Dempster-Shafer evidence theory, and fuzzy logic are described and critiqued. Various related topics are also discussed.

CSc 422. Advanced Topics in Compiling (3)

Topics from general parsers, attributed translation, attribute grammars, two-level grammars, expression optimization, data flow, code optimization, compiler compilers, implementation languages, multi-tasking languages. Prerequisite: CSc 302 or consent of the division head. Gulden

CSc 432. Object-Oriented Software Engineering (3)

Design and construction of modular, reusable, extensible and portable software using statically typed object-oriented programming languages (Eiffel, C++, Objective C). Abstract data types; genericity; multiple inheritance; use and design of software libraries; persistence and object-oriented

databases; impact of object-oriented programming on the software life cycle.

CSc 437. Program Semantics (3)

Theories and techniques of program semantics and program verification. Topics may be chosen from denotational semantics, operational semantics, Floyd-Hoare semantics, temporal logic, dynamic logic, algebraic semantics, continuous semantics, recursive function theory or a current semantic theory. Guiden

CSc 440. Graph Theory and Application (3)

Fundamental concepts of and algorithms for graphs, including: connectivity, planarity, network flows, matchings, colorings, traversals, duality, intractability and applications. Prerequisite: CSc 340 or consent of instructor.

CSc 463. Advanced Issues in Natural Language Processing (3)

Advanced techniques and current applications of natural language systems. Complex syntax and semantics, discourse coherence and planning, natural language interfaces and other applications. Prerequisite: CSc 365 or CSc 465. Blank

CSc 465. Computational Linguistics (3)

Design of natural language systems. Application of linguistic theory and artificial intelligence techniques to development of natural language parsers and generators. Analysis of efficiency and extendibility of such systems; practical applications. Prerequisite: CSc 262. Blank

CSc 492. Special Topics (3)

Topics in computer science not treated in other courses. May be repeated for credit.

Electrical Engineering (ECE)

For Undergraduate Students

ECE 33. Introduction to Computer Engineering (4) fall and spring

Microcomputer organization, architecture, and interfacing. Number systems, Boolean algebra, assembly language programming. Includes a software development laboratory. Prerequisite: Engr 1 or CSc 15 or CSc 17 or equivalent.

ECE 81. Principles of Electrical Engineering (4) fall and spring

Circuit elements and laws. Behavior of simple linear networks. Characteristics of electronic devices and device models. Introduction to functional circuits, such as operational amplifier and logic devices. Principles of electromechanical energy conversion and power systems. Includes a weekly session for review and discussion. Prerequisite: Math 22. Corequisite: Phys 21.

ECE 108. Signals and Systems (4) spring

Continuous and discrete signal and system descriptions using signal space and transform representations. Includes Fourier series, continuous and discrete Fourier transforms, Laplace transforms, and z-transforms. Introduction to sampling. Prerequisite: ECE 81.

ECE 111. Proseminar (1) fall

A weekly seminar to acquaint students with current topics in electrical and computer engineering. Students prepare and present oral and written reports that are judged on quality and presentation as well as technical content. Prerequisite: senior standing.

ECE 116. Software Engineering (3) spring

The software life-cycle; life-cycle models; software planning; testing; specification methods; maintenance. Emphasis on team work and large-scale software systems, including oral presentations and written reports. Prerequisite: CSc 17.

ECE 121. Electronic Circuits Laboratory (2) fall

One lecture and one laboratory per week. Experiments illustrating the principles of operation of electronic devices

and their circuit applications. Basic electronic instrumentation and measurement techniques. Corequisite: ECE 123.

ECE 123. Electronic Circuits (3) fall

Methods for analyzing and designing circuits containing electronic devices. Topics include device models, basic amplifier configurations, operating point stabilization, frequency response analysis, and computer-aided analysis of active circuits. Prerequisite: ECE 108.

ECE 125. Circuits and Systems (3) fall

Formulation of linear circuit equations in the time and frequency domain. Complete solutions of difference and differential equations. Network theorems. Basic stability and feedback concepts. Modulation theory, sampling theory and basic digital signal processing ideas. Prerequisite: ECE 108.

ECE 126. Fundamentals of Semiconductor Devices (3) spring

Introduction to wave mechanics, statistics and the theory of solid-state materials. Principles of electron emission and conduction and their applications. Treatment of semiconductor devices including: p-n junctions, junction luminescence, p-n lasers, Impatt and Gunn devices, and Hall devices. Prerequisite: ECE 81.

ECE 136. Electromechanics (3) spring

Two lectures and one laboratory per week. An experimental introduction to electromechanical energy conversion. Basic concepts of magnetic fields and forces and their application to electrical apparatus including electromechanical transducers, transformers, AC and DC machines. Prerequisite: ECE 81.

ECE 138. Digital Systems Laboratory (2) spring

One laboratory and one lecture per week. Digital measurements, digital instrumentation, logic testing. Characteristics of and design techniques for combinational logic and sequential circuits. Prerequisite: ECE 33 or equivalent.

ECE 162. Electrical Laboratory (1) spring

Experiments on circuits, machines, and electronic devices. Elementary network theory. Survey laboratory for students not majoring in electrical or computer engineering. Prerequisite: ECE 81.

ECE 201. Computer Architecture (3) spring

Digital building blocks, conventional computer structure and information flow. Mechanization of arithmetic, storage, and control functions. Input-output systems and controllers. Priority interrupt, direct memory access and other overlapping techniques. Architecture of small ('mini') computers; key features of large ('maxi') machines. Prerequisite: ECE 33.

ECE 202. Introduction to Electromagnetism (3) spring

Elements of vector analysis, Coulomb's law, Biot-Savart's and Ampere's laws, Lorentz Forces, Laplace's and, Maxwell's equations, boundary conditions, methods of solution in static electric and magnetic fields, including finite element numerical approach. Quasistationary fields, inductance. Prerequisite: Math 205, Phys. 21.

ECE 203. Introduction to Electromagnetic Waves (3) fall

Uniform plane waves in free space and in materials, skin effect. Waves in transmission lines and waveguides, including optical fibers. Energy and power flow, Poynting's theorem. Reflection and refraction. Resonators. Radiation and diffraction. Prerequisite: ECE 202.

ECE 212. Control Theory (3) fall

Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus methods. Nyquist plot, Bode analysis. Cascade compensation techniques. Prerequisite: ECE 125.

ECE 233. Power System Analysis I (3) fall

Determination of transmission line constants: transmission line equations. Synchronous generator representation during steady state and transient conditions. Network reduction by matrix partitioning, network solutions by matrix transformations. Symmetrical components and system faults. Sequence impedances of transmission lines, transformer banks and synchronous generators. Prerequisite: ECE 136.

ECE 234. Power System Analysis II (3)

Load flow applications of the control of power and voltage. Economic dispatch of generation. Short circuit analysis. Power system protection. Basic stability analysis. Engineering Economics. Current topics of interest with the power industry. Prerequisite: ECE 233.

ECE 244. Analog Filters (3)

Approximation of ideal filters by practical filters. Frequency scaling and transformation. Analog filter synthesis using active devices. Switched capacitor implementations of analog filters. Prerequisites: ECE 123 and ECE 125.

ECE 251. Senior Project I (2) fall

This capstone course integrates the knowledge and experience acquired in previous and concurrent courses. Emphasis is on design, implementation, test and evaluation of an engineering project in any of the diverse areas of electrical and computing engineering and computer science consistent with the abilities of the student and departmental resources. A written project proposal, periodic progress reports, a final project report, and a project demonstration are required. Prerequisite: Senior standing.

ECE 252. Senior Project II (2) spring

Same as ECE 251. May be used to substitute for ECE 251 for those students not following the normal schedule. Also serves as a continuation for those projects beyond the scope of a one semester course. Two-three hour sessions per week. Prerequisite: Senior standing.

ECE 254. Microwave-Lightwave Laboratory (2) spring

Basic microwave and optical measurement techniques, design procedures and practical concepts. Practical aspects of fiber optics, optical transmission, and modulation. Two-three hour sessions per week. Corequisite: ECE 346.

ECE 256. Honors Project (1) spring

Open by invitation only to students who have completed ECE 251 Senior Project. Selection is based upon the quality of the senior project with regard to ingenuity, design approach and completeness. The objective of this course is to carry the successful senior projects forward to completion of a technical paper suitable for publication or submission to a technical conference. A written paper and oral presentation are required by mid-semester. Oral presentations will be made before an appropriate public forum. Enrollment limited.

ECE 303. (Mat 323) Characterization of Defects in Semiconductors (3)

Basic concepts of solid state physics applied to p-n junction theory. Topics include influence of material growth techniques on defect origination; dislocations induced by diffusion; oxidation-induced stacking faults; the role of imperfections on pipe leakage and soft breakdowns. The relation of materials, defects and processing will be highlighted. Jaccodine

ECE 308. Physics and Models of Electronic Devices (3)

Physics of metal-semiconductor junction, p-n junctions, and MOS capacitors. Models of Schottky barrier and p-n junction diodes, JFET's, MOSFET's, and bipolar transistors. Prerequisite: ECE 126.

ECE 316. Microcomputer System Design (3) spring

Content is primarily hardware oriented; but software issues are covered where required. Includes performance characteristics of the more popular devices on the market

today. Specific topics include: basic microcomputer structure, bus interconnections, memory systems, serial and parallel interfacing, CRT controllers, interrupt structures, DMA. Prerequisite: ECE 33. Holzinger

ECE 319. Digital System Design (3) fall

Digital techniques on the register transfer level. Implementation of microprogramming, intersystem communication, peripheral interfacing and interrupt handling. VLSI design criteria. Application of AHPS for design verification and simulation. Prerequisite: ECE 33.

ECE 320. Logic Design (3) spring

Review of basic switching theory, vector boolean algebra, canonical implementations of medium size circuits, threshold logic, fault detection in combinational and sequential logic, Multivalued and Fuzzy logic, regular expressions, nondeterministic sequential machines. Prerequisite: ECE 33.

ECE 332. Design of Linear Electronic Circuits (3) spring

Introduction to a variety of linear design concepts and topologies, with contemporary audio networks providing many of the concrete examples. Topics include low- and high-level preamps; equalizers and filters; mixers; voltage-controlled amplifiers; input and output stage modifications; power amplifiers; analog switching and digital interface circuitry. Prerequisite: ECE 355. Frey

ECE 342. Communication Theory (3) spring

Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: ECE 125 and Math 309 or Math 231.

ECE 343. Digital Signal Processing (3) fall

Study of orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transform. Development of fast algorithms to compute these, with applications to speech processing and communication. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: ECE 108.

ECE 345. Speech Synthesis and Recognition (3) spring

Application of digital technology to generation and recognition of speech by machines. The analytical tools required for digitizing and encoding speech signals; the methods currently used for synthesizing and recognizing speech; various hardware products available to perform these tasks. Holzinger

ECE 346. Microwave Circuits and Techniques (3) spring

Impedance transformation along waveguides. Matching techniques. Applications of Smith Chart. Resonators as circuit elements. Scattering and transfer matrices. S-parameter design of transistor amplifiers. Stability. Noise. Reflection type amplifiers. Prerequisite: ECE 203 or equivalent. Eberhardt

ECE 348. Lightwave Technology (3) spring

Overview of optical fiber communications. Optical fibers, structures and waveguiding fundamentals. Signal degradation in fibers arising from attenuation, intramodal and intermodal dispersion. Optical sources, semiconductor lasers and LEDs. Rate equations and frequency characteristics of a semiconductor laser. Coupling efficiency of laser diodes and LEDs to single-mode and multimode fibers. PIN and avalanche photodetectors. Optical receiver design. Transmission link analysis. Prerequisite: ECE 203.

ECE 350. Special Topics (3)

Selected topics in the field of electrical and computer engineering not included in other courses. May be repeated for credit.

ECE 351. Microelectronics Technology (3) fall

Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, lithography. The major emphasis will be on silicon technology, with additional lectures on GaAs technology. Prerequisites: ECE 126 and Phys 31.

ECE 355. Applied Integrated Circuits (3) fall

Emphasis on understanding of terminal characteristics of integrated circuits with excursion into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multipliers, modulators, and phase-locked loops. Prerequisites: ECE 123 and 125. Holzinger

ECE 361. Introduction to VLSI Circuits (3) fall

The design of Very Large Scale Integrated Circuits, with emphasis on CMOS Standard Cell design. Topics include MOS transistor physics, device behavior and device modeling, MOS technology and physical layout, design of combinational and sequential circuits, static and dynamic memories, and VLSI chip organization. The course includes a design project using CAE tools for layout, design rule checking, parameter extraction, and SPICE simulations for performance prediction. Two one-hour lectures and three hours of laboratory per week. Prerequisite: ECE 123.

ECE 362. Introduction to VLSI System Design (3) spring
Structured hierarchical approach to the design of digital VLSI circuits and systems. Use of CAE tools for design and verification. Topics include: systems aspects of VLSI design, design methodologies, schematic capture, functional verification, timing simulation, use of a CMOS standard cell library and of a silicon compiler. The course includes a semester-long design project, with the design to be fabricated by a foundry. Two one-hour lectures and three hours of design laboratory per week. Prerequisite: ECE 361.

ECE 387. (ChE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware: discrete state variables; state transition matrix; Liapunov stability; state feedback control. Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor.

ECE 389. Control Systems Laboratory (2)

Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: ChE 386, ME 343, ECE 212.

For Graduate Students**ECE 401. Advanced Computer Architecture (3)**

Design, analysis and performance of computer architectures; high speed memory systems; cache design and analysis; modeling cache performance; principle of pipeline processing; performance of pipelined computers; scheduling and control of a pipeline; classification of parallel architectures; systolic and data flow architectures; multiprocessor performance; multiprocessor interconnections and cache coherence. Prerequisite: ECE 201 or equivalent.

ECE 404. Computer Networks (3)

Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and

error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy. Tzeng

ECE 407. Linear and Nonlinear Optics (3)

Diffraction theory, Gaussian beams. Optical resonators and waveguides. Crystal optics, second harmonic generation, parametric amplification. Third order nonlinearities and associated phenomena such as phase conjugation, optical bistability, self-focusing, optical switching, solitons, etc. Photorefractive effect. Brillouin and Raman scattering. Christodoulides

ECE 411. Information Theory (3)

Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces study of discrete-stochastic information courses, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Fritchman

ECE 412. Advanced Digital Signal Processing (3)

Design and analysis of signal processing algorithms, Number theoretic foundations of algorithm design, bilinear algorithms, computational techniques for digital filtering and convolution, Fourier transform and its algorithms, number theoretic transforms and applications to digital filtering, general and special purpose signal processor designs, application specific techniques in signal processing. Prerequisite: ECE 343 or consent of the department chairman. Wagh

ECE 413. Data Communication (3)

Review of data transmission system evolution. Description of devices and techniques used for reliable transmission of data between systems connected by point-to-point data links. Study of protocols and equipments used in terminal-oriented distributed computing systems. Review of different types of communication protocols using queueing theory for analysis of their fundamental properties.

ECE 415. Numerical Processors (3)

Design strategies for numerical processors, cellular array adders and multipliers, conditional sum and carry-save asynchronous processors, data recoding and Booth's algorithms, use of alternate numerical bases, CORDIC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Wagh

ECE 416. VLSI Signal Processing (3)

The fundamentals of performance-driven VLSI systems for signal processing. Analysis of signal processing algorithms and architectures in terms of VLSI implementation. VLSI design methodology. Includes a design project which requires use of a set of tools installed on SUN workstations for behavioral simulation, structural simulation, circuit simulation, layout, functional simulation, timing and critical path analysis, functional testing, and performance measurement. Prerequisite: ECE 361, ECE 343, or equivalent. Li

ECE 424. Advanced Circuits and Systems (3)

Review of linear circuit and system analysis including time domain and frequency domain solution techniques. Overview of contemporary mathematical and circuit-theoretic techniques applied to the solution of linear circuits— including, fundamental loop and cutset equations, generalized nodal, modified nodal, tableau, and mesh equation formulation, hybrid N-port network description and state equation formulation, and selected matrix and linear operator theory relevant to the solution of system equations. Discretization and computer based circuit analysis will be a fundamental theme of the course. Nonlinear and time-varying networks will be discussed in this context. Frey

ECE 431. Topics in Switching Theory (3)

Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, decomposition techniques, synthesis with assumed network forms, systolic architectures, systolic lemma and its applications, bit serial architectures. Prerequisite: ECE 320 or equivalent. Wagh

ECE 432. Finite State Machines (3)

Structure of sequential machines. State minimization. State Partitions. Properties and synthesis of finite automata. Linear sequential machines over finite fields. State-space analysis and properties of linear sequential machines. Synthesis of regular expression recognizers. Prerequisite: ECE 320 or consent of the instructor. Wagh

ECE 433. (ChE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor.

ECE 434. (ChE 434, ME 434) Multivariable Process Control (3)

A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 435. Error-Correcting Codes (3)

Error-correcting codes for digital computer and communication systems. Review of modern algebra concentrating on groups and finite fields. Structure and properties of linear and cyclic codes for random or burst error correction covering Hamming, Golay, Reed-Muller, BCH and Reed-Solomon codes; construction of Goppa codes and their recent generalizations. Decoding algorithms and implementation of decoders. Prerequisite: CSc 261 or equivalent. Tzeng

ECE 436. (ChE 436, ME 436) Systems Identification (3)

The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-embedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 437. (ChE 437, ME 437) Stochastic Control (3)

Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 441. Advanced Electromagnetic Theory (3)

Maxwell's equations in Cartesian and curvilinear coordinates. Vector and scalar potentials. Lorentz and Coulomb gauges. Lorentz reciprocity theorem. Boundary

value problems—Green's functions. Waveguide theory. Scattering matrix formulation. Radiation of electromagnetic waves. Antenna theory. Diffraction theory. Integral transform techniques. Prerequisite: ECE 203 or equivalent.

ECE 444. Microwave Devices (3)

Basic theory, design theory and intuitive understanding is developed for passive and active devices and special circuitry used in microwave systems: circulators, isolators, directional couplers, periodic structures, parametric amplifiers, masers, magnetrons, and klystrons. Semiconductor devices are only discussed by their terminal characteristics. Eberhardt

ECE 447. Nonlinear Phenomena (3)

Investigation of nonlinear effects in active and passive lumped and distributed circuits with emphasis on methods of analysis as well as physical understanding of jump phenomena, van derPol's theory, stability criteria, phase locking. Transmission line and optical waves in nonlinear media; shock waves, harmonic generation and optical parametric amplification. Eberhardt

ECE 450. Special Topics (3)

Selected topics in electrical and computer engineering not covered in other courses. May be repeated for credit.

ECE 451. Physics of Semiconductor Devices (3)

Crystal structure and space lattices, crystal binding, lattice-waves and vibrations, electrons and atoms in crystal lattices. Quantum mechanics and energy band theory, Carrier statistics, Boltzmann transport theory, interaction of carriers with scattering centers, electronic and thermal conduction. Magnetic effects. Generation and Recombination Theory. Application to p-n junctions. Prerequisites: Phys 31 and ECE 126 or equivalent. Decker or White

ECE 452. Advanced Semiconductor Diode and Transport Theory (3)

Properties of metal-semiconductor contacts, Schottky barriers, ohmic contacts, hot electrons, intervalley scattering, velocity saturation, secondary ionization, avalanche breakdown. Applications to microwave devices such as avalanche and Gunn diodes, Schottky barrier diodes, tunnel diodes and PIN diodes. Prerequisite: ECE 451. Decker

ECE 454. Theory of Optoelectronic Devices (3)

Optical electronics. Theory of radiation, radiative absorption and emission in semiconductors. Applications to optical electronic devices: electroluminescence, light-emitting diodes, lasers. Detection and modulation of optical radiation, solar cells and photodetectors. Prerequisite: ECE 451. Decker

ECE 455. Theory of Metal Semiconductor and Heterojunction Transistors (3)

Physics of metal semiconductor and heterojunction field effect transistors (MESFET and HEMT). Theory of semiconductor heterojunctions. Properties of heterojunction bipolar transistors (HBT): Equivalent circuits, applications to microwave amplifiers, oscillators, and switching circuits. Prerequisite: ECE 451. Decker

ECE 460. Engineering Project (3-6)

Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of department chairperson.

ECE 461. Theory of Electrical Noise (3)

Definitions: noise temperature, spectral density. Noise sources: quantum, thermal, shot, generation-recombination, flicker noise. Representation and optimization of noisy networks. Prerequisites: Phys 31 and ECE 126. Decker

ECE 463. Design of Microwave Solid State Circuits (3)

Equivalent circuit modeling and characterization of microwave semiconductor devices, principles of impedance

matching, noise properties and circuit interaction, introduction to the design of high power and non-linear circuits. Decker

ECE 468. Solid-State Microelectronics Technology (3)

Laboratory fabrication of CMOS/Bipolar integrated circuits and device test structures. The emphasis is on practical aspects of IC fabrication including silicon wafer cleaning, gettering of defects, oxidation, diffusion, ion-implantation, photolithography, chemical vapor deposition, plasma and wet-chemical processes, and vacuum evaporation/sputtering of metal and dielectric films. Contamination and safety are emphasized throughout the process sequence. In-process monitors and computer simulation of technology steps are combined with laboratory experiments. Each student fabricates a complete IC 'chip' and performs technology evaluation with on-chip test structures. Registration by consent of instructor. Prerequisite: ECE 351 or equivalent. White and staff

ECE 469. Process Modeling for Semiconductor Devices (3)

Students will design and "manufacture" a Si or GaAs transistor through process simulation of ion implantation, epitaxial growth, diffusion and contact formation, etc. I-V characteristics and small signal parameters, suitable for digital and microwave circuit simulation programs, will be derived. Complementary to ECE 463 and 471. Prerequisite: ECE 308 or 351. Hwang and Varnerin

ECE 471. Device Modeling for VLSI Circuits (3)

VLSI design requires computer aids for all aspects of the design and verification process. This course will take a close look at the physics of the device models of the various semiconductor components, and how these models have been implemented in SPICE. Course coverage will include the various well-established models, such as the Gummel-Poon model of the bipolar transistor, as well as the second-order effects of both bipolar and field-effect devices. Prerequisite: ECE 308. Hielscher

ECE 474. Analog CMOS VLSI Design (3)

The fundamentals of analog circuit design with CMOS linear IC techniques. Discrete Analog Signal Processing (DASP) is accomplished with switched-capacitor CMOS circuits. Analog building blocks include operational amplifiers, S/H circuits, comparators and voltage references, oscillators, filters, modulators, phase detectors/shifters, charge transfer devices, etc. Analog sub-system applications are phase-locked loops (PLL's), A/D and D/A converters, modems, sensors, adaptive filters and equalizers, etc. The emphasis is on the physical operation of analog CMOS integration circuits and the design process. Prerequisite: ECE 355 or equivalent. White

ECE 476. Analysis and Design of Analog Integrated Circuits (3)

Device and circuit models of bipolar and field effect transistors; bipolar and MOS integrated circuit technology; passive components; parasitic and distributed elements; amplifier gain stages; subthreshold gain stages; current sources and active loads; temperature and supply-independent biasing; output stage design; frequency response and slew rate limitation; operational amplifier and analog multiplier design. Circuit simulation using SPICE or SLICE. Prerequisite: ECE 471 or equivalent. Hielscher

ECE 478. Analysis and Design of Digital Integrated Circuits (3)

Large signal models and transient behavior of MOS and bipolar transistors. Basic inverter and logic gate circuits. Noise margins, operating speed, and power consumption of various logic families, including MOS, CMOS, saturated logic TTL, ECL, and 11.2L. Regenerative logic circuits and digital memories. Circuit design and computer aided circuit analysis for LSI and VLSI circuits. Prerequisite: ECE 471. Hielscher

ECE 479. Advanced MOS VLSI Design (3)

The design of very large scale NMOS and CMOS integrated circuits. Strong emphasis on device physics, and on novel circuit design approaches for VLSI implementation. Examination of second-order effects involved in designing high-performance MOS digital integrated circuits, with the goal of pushing the design process to the limits determined by our current understanding of semiconductor device physics and of the currently available technologies. The topics include device physics (subthreshold conduction, short-channel effects), important circuit innovations (substrate-bias generators, sense amplifiers), systems aspects (clocking, timing, array structures), as well as static and dynamic circuit implementations. Design project, using VLSI design automation tools. Prerequisites: ECE 361 and ECE 471. Hielscher

ECE 483. Advanced Semiconductor Devices for VLSI Circuits (3)

Theory of small geometry devices for VLSI circuits. Emphasis of MOS bipolar device static and dynamic electrical characteristics. Carrier injection, transport, storage, and detection in bulk and interfacial regions. Limitations of physical scaling theory for VLSI submicron device structures. MOS physics and technology, test pattern device structures, charge-coupled devices, MNOS nonvolatile memory devices, and measurement techniques for device and process characterization. The influence of defects on device electrical properties. Prerequisite: ECE 451. White

ECE 484. Dielectric Materials in VLSI and Optoelectronics (3)

Electronic and optical properties of silicon dioxide and other dielectric materials, including optical excitations, charge carrier transport and trapping, and interface phenomena. Applications to dielectric crystal, film, used in VLSI technologies. Emphasis on specific topics of current interest. Prerequisite: ECE 451 or equivalent. Young

ECE 485. Heterojunction Materials and Devices (3)

Material properties of compound semiconductor heterojunctions, quantum wells and superlattices. Strained layer epitaxy and band-gap engineering. Theory and performance of novel devices such as quantum well lasers, resonant tunneling diodes, high electron mobility transistors, and heterojunction bipolar transistors. Complementary to ECE 452. Prerequisite: ECE 451. Hwang and Varnerin

ECE 486. Integrated Solid-State Sensors (3)

The physical operation of sensor-based, custom integrated circuits. Emphasis on the integration of sensors, analog, and digital circuits on a silicon chip with CMOS technology. Sensors include photocells, electrochemical transducers, strain gauges, temperature detectors, vibration and velocity sensors, etc. Analysis of sensor-circuit performance limits including signal-to-noise, frequency response, temperature sensitivity, etc. Examples of sensor-based, custom I.C.'s are discussed and analyzed with CAD modeling and layout. Prerequisite: ECE 451. White

ECE 493. Solid State Electronics Seminar (3)

Discussion of current topics in solid-state electronics. Topics selected depend upon the interests of the staff and students and are allied to the research programs of the Sherman Fairchild Laboratory for Solid State Studies. Student participation via presentation of current research papers and experimental work. Prerequisite: consent of instructor. May be repeated for credit.

Electrical Engineering

See listings under Electrical Engineering and Computer Science.

Electrical Engineering and Engineering Physics

This curriculum is particularly well suited for students seeking thorough preparation in the field of electronic device physics. The program is a combination of the basic electrical engineering and engineering physics curriculums.

Students who follow the course sequence below will earn the B.S. in electrical engineering at the end of the fourth year (133 credit hours) and the B.S. in engineering physics at the end of the fifth year (165 credit hours). An alternate course sequence, in which the B.S. in engineering physics is conferred at the end of the fourth year (129 credit hours) and the B.S. in electrical engineering after the fifth year (165 credit hours) is also available. Interested students should contact Prof. S.H. Radin, department of physics.

freshman year in engineering (see page 34)

sophomore year, first semester (17 credit hours)

ECE 81	Principles of Electrical Engineering (4)
ECE 33	Introduction to Computer Engineering (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)

sophomore year, second semester (16 credit hours)

ECE 108	Signals and Systems (4)
Math 205	Linear Methods (3)
Phys 31	Intro. to Quantum Mechanics (3)
Eco 11 or 12	Micro- or Macroeconomics (3)
	HSS (3)

junior year, first semester (17 credit hours)

ECE 123	Electronic Circuits (3)
ECE 121	Electronic Circuits Laboratory (2)
ECE 125	Circuits and Systems (3)
Math 231	Probability and Statistics (3)
Phys 212	Electricity and Magnetism I (3)
	HSS (3)

junior year, second semester (17 credit hours)

ECE 126	Fundamentals of Semiconductor Devices (3)
ECE 136	Electromechanics (3)
ECE 138	Digital Systems Laboratory (2)
Phys 213	Electricity and Magnetism II (3)
Math 208	Complex Variables (3)
	HSS (3)

senior year, first semester (18 credit hours)

ECE 111	Proseminar (1)
ECE 251	Senior Project I (2)
Phys 215	Classical Mechanics I (3)
ECE	departmental elective (3)
	HSS (3)
	free electives (6)

senior year, second semester (18 credit hours)

Phys 362	Atomic and Molecular Structure (3)
Phys 264	Nuclear and Elementary Particle Physics (3)
ECE	departmental electives (9)
	free elective (3)

fifth year, first semester (17 credit hours)

Phys 216	Classical Mechanics II (3)
Phys 273	Research (2-3) or
Phys 260	Laboratory Techniques (2)
Phys 340	Thermal Physics (3)
Math 322	Methods of Applied Analysis I (3)

approved elective** (3)

free elective (3)

Fifth year, second semester (15 credit hours)

Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 171	Physics Proseminar (1)
	approved electives** (3)
	free electives (9)

**Approved electives include two courses selected from Phys 363, 369, (352 or 355), and (346 or 348 or 365).

Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives.

Engineering

Engr 1 is required of all engineering and applied science majors and is taken in the recommended freshman year.

1. Engineering Computations (3) fall-spring

Introduction to the solution of engineering problems through the use of the computer. Elementary computer programming in FORTRAN is taught and illustrated by means of several topics in computational mathematics such as roots of equations, matrices, least squares analysis, numerical integration, and others. No previous knowledge of computer programming is assumed. Also, a series of lectures and demonstration is given, outlining the career opportunities available in the various disciplines represented in the College of Engineering and Applied Science. Prerequisite: Math 21 or 31, previously or concurrently. Wiginton

250. Computer Modeling of Scientific and Engineering Systems (3) fall

Introduction to the mathematical modeling of scientific engineering systems, with emphasis on higher-order nonlinear models for which analytical methods are precluded. Solution of the model equations by computer-based numerical algorithms. Introduction to numerical methods for linear and nonlinear algebraic systems, ordinary and partial differential equations, error analysis and control, stability and convergence in numerical calculations. Prerequisites: Engr 1; Math 205, previously or concurrently.

475. Research (1)

Projects conducted under the supervision of a faculty advisor. Includes analytical, computational or experimental work, literature searches, assigned readings. Regular meetings with the advisor to consider progress made and future direction are required. The course is open only to graduate students and may be repeated for credit. Prerequisite: Graduate standing and departmental approval.

Engineering-M.B.A. Program

The bachelor in engineering-master of business administration two-degree program is designed to meet the needs of especially competent students in any engineering curriculum who want to add to their engineering studies training in business management at an advanced level.

The time involved will vary depending on the student's background. One or more summer sessions in addition to two or more regular semesters of study may be necessary after completion of the bachelor's degree in engineering to attain the M.B.A. or M.S. in management science. All candidates must take the Graduate Management Admission Test and must meet the standards for admission into The Graduate School.

For background courses required for the master of business administration program, engineering students should read Section IV, Graduate Study in Business and

Economics, and consult with Kathleen Trexler, Assistant Dean and MBA Director, College of Business and Economics.

Engineering Mathematics

Professors. Philip A. Blythe, Ph.D. (Manchester, England) *head*; Terry J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Alistair K. Macpherson, Ph.D. (Sydney); Kenneth N. Sawyers, Ph.D. (Brown); George C. M. Sih, Ph.D. (Lehigh); Gerald F. Smith, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); J. David A. Walker, Ph.D. (Western Ontario). **Associate professors.** D. Gary Harlow, Ph.D. (Cornell). **Assistant professors.** Antonios Liakopoulos (Florida). The *Division of Engineering Mathematics* was established within the Department of Mechanical Engineering and Mechanics to foster interdisciplinary research in the application of mathematics to the engineering and physical sciences. Interaction with industry is actively encouraged, and appropriate programs are designed for part-time students. Program content for all students is developed through close consultation with Division faculty.

For a description of the graduate programs in Applied Mathematics see the discussion under Interdisciplinary Graduate Programs on page 50 in Section IV. Engineering Mathematics courses are listed under Mechanical Engineering and Mechanics.

English

Professors. Edward J. Gallagher, Ph.D. (Notre Dame), *chairperson*; Rosemarie A. Arbur, Ph.D. (Illinois); Peter G. Beidler, Ph.D. (Lehigh); *Lucy G. Moses Distinguished Professor*; Jack A. DeBellis, Ph.D. (U.C.L.A.); Jan S. Fergus, Ph.D. (C.U.N.Y.); Elizabeth N. Fifer, Ph.D. (Michigan); James R. Frakes, Ph.D. (Pennsylvania); *Edmund W. Fairchild Professor of American Studies*; Albert E. Hartung, Ph.D. (Lehigh), *Distinguished Professor*; Rosemary J. Mundhenk, Ph.D. (U.C.L.A.); Barbara H. Traister, Ph.D. (Yale); John F. Vickrey, Ph.D. (Indiana). **Associate professors.** Addison C. Bross, Ph.D. (Louisiana State); Alexander M. Doty, Ph.D. (Illinois); Robert R. Harson, Ph.D. (Ohio); Edward E. Lotto, Ph.D. (Indiana), *head of The Learning Center*; Barbara Pavlock, Ph.D. (Cornell). **Assistant professors.** David Hawkes, Ph.D. (Columbia). **Adjunct professors.** Ellen Bonds, M.A. (West Chester); Susan Haymanek, M.A. (Lehigh); Karen R. Keim, Ph.D. (Indiana); Carolyn Segal, Ph.D. (Lehigh).

"Nature is a Haunted House," Emily Dickinson wrote to a friend in 1876, "but Art—a House that tries to be haunted." In the Department of English we try to tease forward the spirits that give life to houses built of words.

Undergraduate Major in English

The major in English is designed to give students experience in reading, analyzing, and formulating thoughts about people and ideas that matter; an understanding of how literary artists find the appropriate words to express their thoughts and feelings; and a basic knowledge of the historical development of British, American and world literature.

Students who major in English go on to careers in teaching, writing, law, business, science, medicine, engineering—and many others. The analytical and communication skills acquired in the study of literature and writing will be of use in almost any profession or human activity. Depending on their interests, abilities, and career plans, students who major in English are encouraged to consider double majors or one or two minors in other fields.

The major in English is flexible enough to allow cross-disciplinary study with ease.

The student majoring in English chooses from an extensive list of courses. To ensure breadth of coverage and a deeper study of two major writers, each English major is required to take the following courses:

Engl 123, American Literature I,
Engl 125, British Literature I, and
Engl 126, British Literature II;

either

Engl 329, Shakespeare and Elizabethan Drama, or
Engl 330, Shakespeare and Elizabethan Drama;

and either

Engl 327, Chaucer, or
Engl 331, Milton.

In addition, each English major elects at least five more courses in literature or film distributed as follows:

at least three courses at the 300-level, and
at least two courses in literature before 1900.

These ten courses are the *minimum* for the major. Many of our students will elect to take more, depending on their career plans, their other majors and minors, their plans to study abroad, and so on. Each major has a departmental advisor to assist in selecting courses and to offer counsel about career plans.

The department strongly recommends that any student contemplating the possibility of advanced study of literature at the graduate level should work toward departmental honors.

Departmental Honors in English

In order to receive departmental honors the English major must attain a 3.3 grade-point average in courses presented for the major and must complete at least 36 credit hours of course work in English (beyond English 1 and 2). For the additional credits beyond the 30 required of all English majors, honors students must take one of the following three courses:

Engl 248, Introduction to the English Language, or
Engl 387, Film History and Criticism, or
Engl 391, Interpretative Approaches to Literature;

and either

Engl 381 (or 382), Thesis, or
Engl 4-, a graduate seminar, by petition.

Because most graduate schools require language examinations, the department also strongly recommends that students going for honors achieve at least second-year college competency in at least one foreign language. Students who complete the courses required for departmental honors but who do not achieve the necessary grade-point average will receive the bachelor of arts degree with a major in English.

Minors in English

The Department of English offers three minors, each requiring fifteen hours of course work beyond English 1 and 2. Students major advisors monitor the minor programs, but students should consult the minor advisor in the Department of English when setting up a minor program.

To minor in British literature, students take Engl 125, Engl 126, and three more courses in British literature, at least two of them at the 300-level.

To minor in American literature, students take Engl 123, Engl 124, and three more courses in American literature, at least two of them at the 300-level.

To minor in writing, students take Engl 171 and one of

these three courses: Engl 347, Engl 348, or Engl 373. They must also take three more courses chosen from Engl 173, 174, 201, 248, 281, Journ 11, 12, 123, or any literature courses designated writing intensive (WI).

Graduate Work in English

We prepare our students to meet contemporary demands for faculty who value excellence in teaching and scholarship.

The Master of Arts Program

Applicants for the M.A. program should have an undergraduate English major. Students who did not major in English may be admitted but will need to supplement their undergraduate training in English.

Candidates for the master's degree must complete at least thirty credit hours. Students take at least seven of the required courses (including "thesis papers") at the 400-level but may select the balance of their curricula from 300-level course offerings. Course work for the M.A. must include two courses in literature before 1660; two courses in the period between 1660 and 1900; two courses from 1900 to the present; and one course in literary theory. At least two of these courses must be in American literature and at least four in British literature. Up to six hours of collateral work in other departments may be included in a master's program.

Instead of writing the traditional "thesis," M.A. candidates write two or three shorter "thesis papers," certified by faculty advisors as ready for submission to a session-organizer as a conference presentation or to a professional journal for possible publication.

The Doctor of Philosophy Program

The department admits to its doctoral program only students of proven competence and scholarly promise. An average of 3.5 in M.A. course work and strong endorsements from graduate instructors are minimum requirements for acceptance.

Doctoral candidates with a Lehigh master's degree must register for 42 credit hours beyond the M.A. Those entering the doctoral program with a master's from another institution must register for 48 credit hours. Candidates take at least twenty-four hours of course work beyond the M.A., including at least one course from the following sequence: English 421 (History of the English Language), English 423 (Old English), and English 424 (*Beowulf*).

Candidates must also demonstrate a reading knowledge of one or two foreign languages after having agreed on choices with the Director of Graduate Studies.

No later than six months after completing their course work, candidates will take written and oral examinations in one major field and two minor fields.

Candidates write their dissertations after having their dissertation proposals approved by the department and being admitted to candidacy by the Graduate School.

Freshman Composition Requirement

With the two exceptions noted below, all undergraduate students take six credit hours of freshman English courses: English 1 and one of the five options for the second semester, Engl 2, 4, 6, 8, 10. The exceptions are:

1. Advanced placement and six hours of Lehigh credit for freshman English are given to students who earn a score of 5 on the College Board Advanced Placement Test in English. Students who receive a grade of 4 on the Advanced Placement Test in English or who have a score of 700 or higher on the SAT Verbal Aptitude Test or the English Composition Achievement Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking an English course suggested by the department. Students who have an SAT Verbal Aptitude Test or English Composition Achievement Test score between 650 and 699 or who have received a grade of 3 on the College board Advanced Placement Test in English may apply to the department for a special examination given during orientation, which, if completed successfully, will result in three hours of credit and exemption from Engl 1.

2. Students with English as a Second Language.

Categories include students on non-immigrant visas, students on immigrant visas, registered aliens, and citizens either by birth or by naturalization.

Students in all these categories for whom English is not the first language may petition for special instruction through the program in English as a Second Language.

At matriculation, all foreign students take an English-language competence test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will roster Engl 1, followed by Engl 2, 4, 6, 8, or 10. Others will be enrolled in Engl 3, followed by Engl 5 (or 2, 4, 6, 8, or 10).

Students enrolled in the English as a Second Language program are expected to reach a level of competence comparable to those in the usual freshman program. The form of instruction, however, will differ in the ESL program by taking into account the special problems of non-native speakers.

Matriculating students in all the above categories who are entering at a level above the freshman year, but who need composition credit, should consult the department for advice.

Freshman Courses

1. Composition and Literature (3)

The art of expository writing. Appropriate collateral reading.

2. Composition and Literature: Fiction, Drama, Poetry (3)

Continuation of Engl 1. Further practice in expository writing in conjunction with the study of fiction, drama, and poetry. Prerequisite: Engl 1.

3. English as a Second Language (3)

Idiomatic English both oral and written, with a strong emphasis on producing well-organized, coherent essays. Enrollment limited to non-native speakers; placement is determined after testing by the Department of English.

4. Composition and Literature: The Novel (3) spring

Continuation of Engl 1. Further practice in expository writing in conjunction with study of selected novels. Prerequisite: Engl 1.

5. English as Second Language II (3)

Continuation of English 3.

6. Composition and Literature: Drama (3) spring

Continuation of Engl 1. Further practice in expository writing in conjunction with the study of literary and theatrical aspects of several classic and contemporary plays. Prerequisite: Engl 1.

8. Composition and Film Study (3) spring

Continuation of Engl 1. Further practice in expository writing in conjunction with the study of film. Prerequisite: Engl 1.

10. Composition and Literature: Fiction (3) spring

Continuation of Engl 1. Further practice in expository writing in conjunction with the study of short stories, novellas, and novels. Prerequisite: Engl 1.

11. Literature Seminar for Freshmen (3) fall

Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement.

12. Literature Seminar for Freshmen (3) spring

Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement. After passing Engl 1, students judged to be qualified may complete the English composition requirement by taking this course instead of Engl 2, 4, 6, 8, or 10.

Undergraduate Courses

English 50, 54, 56, and 58 are open to all undergraduates, including first-year students also taking freshman English. Courses numbered at the 100-level are open to students who have completed or who are exempt from the required six hours of freshman English. First-year students who have completed English 1 with a grade of A or A- may roster one of the 100-level courses as a second English course to be taken concurrently with the second-semester English composition requirement.

Prerequisites. Each course is a self-contained unit. None has any other prerequisite than two semesters of freshman English. Thus, students may roster English 126 whether or not they have had, or ever plan to take, English 125. For all courses above 200, it is understood that students will have completed six hours of freshman English, even though that is not specified in the course description.

52. Classical Epic (3)

Study of major epic poems from Greece and Rome. Works include Homer's *Illiad* and *Odyssey*, Apollonius' *Argonautica*, Vergil's *Aeneid*, and Ovid's *Metamorphoses*. Pavlock

54. Greek Tragedy (3)

Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock

56. The Ancient Novel (3)

Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlok

58. Greek and Roman Comedy (3)

Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock

85. Performing Literature (1-3)

Study of and practice in literature to be performed before an audience. Title will vary. May be repeated for credit as title varies.

91. Special Topics (1-3)

A topic, genre, or approach in literature or writing not covered in other courses.

122. Speculative Fiction (3)

From 'hard SF' to high fantasy. The fusing of aesthetic, philosophical, scientific and technological orientations in the literature of our post-atomic culture. Prerequisite: six hours of freshman English. Arbur

123. American Literature I (3)

Significant American writing from the settlement through the middle of the 19th century. Prerequisite: six hours of freshman English.

124. American Literature II (3)

American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English.

125. British Literature I (3)

British literature from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English.

126. British Literature II (3)

British literature from Wordsworth to Auden. Prerequisite: six hours of freshman English.

129. Shakespeare and Elizabethan Drama (3) fall

Study of the earlier plays of Shakespeare, mostly comedies and histories. Selected plays from contemporary dramatists such as Marlowe, Greene, and Jonson. Meets with Engl 329, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Traister

130. Shakespeare and Elizabethan Drama (3) spring

Study of the later plays of Shakespeare, the tragedies and

romances. Selected plays from contemporary dramatists such as Webster, Tourneur, Middleton. Meets with Engl 330, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Traister

151. The Drama (3)

Selected plays; theories of drama; drama and the stage. Prerequisite: six hours of freshman English.

153. The Short Story (3)

English, American, and continental short story. Class discussions, collateral reading, and reports. Prerequisite: six hours of freshman English.

155. The Novel (3)

Selected novels as works of literature. Prerequisite: six hours of freshman English.

157. Poetry (3)

Traditional and modern poetry read for pleasure and understanding. Prerequisite: six hours of freshman English.

159. World Literature (3)

Great works from the literature of epic poetry, drama, romance, and essay that illustrate the humanistic traditions of Western civilization. Prerequisite: six hours of freshman English.

163. Narrative Film (3)

History and aesthetics of narrative film. May be repeated for credit as title varies. Prerequisite: six hours of freshman English. Doty

171. Practical Writing (3)

Practice in and criticism of expository writing beyond the freshman level. Prerequisite: six hours of freshman English.

173. Personal Writing (3)

Practice in writing from immediate experience, with emphasis on accurate, persuasive descriptive writing.

174. Creative Writing Workshop (3)

Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry; etc. May be repeated for credit. Prerequisite: six hours of freshman English.

175. Individual Authors (1-3)

Intensive study of the works of one or more literary artists. Title will vary: Hemingway; Tolkien. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

177. Individual Works (1-3)

Intensive study of one or more literary works. Title will vary: Moby Dick; Stories of John Cheever. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

179. Character Types in Literature (1-3)

Study of a character type in several works of literature by several authors. Title will vary: The Scientist in Drama and Fiction; The Magician in Literature. May be repeated for credit as the title varies. Prerequisite: six hours of freshman English.

181. Undergraduate Thesis (3)

Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chairperson.

182. Undergraduate Thesis (3)

Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson.

183. Readings in English and American Literature (3)

Open to advanced students who wish to pursue special or

independent courses of reading in literary study.
Prerequisite: consent of the department chairperson.

187. Themes in Literature (1-3)

Study of a recurring theme as it appears in several works of literature. Title will vary: Utopian Literature; Censorship and Literature. May be repeated for credit as title varies.
Prerequisite: six hours of freshman English.

189. Popular Literature (1-3)

A form of literature that is or has been of interest primarily to a 'popular' audience. Title will vary: Folklore; Detective Fiction. May be repeated for credit as title varies.
Prerequisite: six hours of freshman English.

191. Special Topics (1-3)

A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English.

201. Special Topics in Writing (1-3)

Approaches not covered in other writing courses. Individual projects. May be repeated for credit. Prerequisite: Engl 171, or consent of department chair.

248. Introduction to the English Language (3)

Basic linguistic concepts together with a historical survey of the English language. Vickrey

281. Internship (3)

Projects on or off campus in business, professional, or government organizations. Projects approved by department committee on internships and supervised by department internship adviser. Project includes extensive writing that can be submitted for evaluation. Enrollment limited to juniors or seniors with a major or minor in English. Prerequisite: consent of department chair. Harson

291. Special Topics (1-3)

A topic, genre, or approach in literature or writing not covered in other courses.

301. Topics in Literature (1-3)

A theme, topic, or genre in literature. Title will vary: Autobiography as Literature; British Drama. May be repeated for credit as title varies.

311. Literature of Women (WS 311) (3)

Women's works about women: is literary creativity gender-identified? Are there specifically "feminine" subjects or themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works by less famous writers. Arbur

312. Jewish Literature (3)

Development of Jewish literature (including Yiddish literature in translation) from Russian and Eastern European beginnings to immigration and assimilation in America. Fifer

316. The Indian in American Literature (3)

The American Indian as portrayed in folklore, poetry, and fiction in America. Works written by both Indian and non-Indian writers. Beidler

327. Chaucer (3)

The chief works of the "father of English Literature." Focus on Chaucer's language, on the literary, historical and social backgrounds to his work, and on his masterpiece, the *Canterbury Tales*. Beidler

329. Shakespeare and Elizabethan Drama (3) fall

Study of the earlier plays of Shakespeare, mostly comedies and histories. Selected plays from contemporary dramatists such as Marlowe, Greene, and Jonson. Traister

330. Shakespeare and Elizabethan Drama (3) spring

Study of the later plays of Shakespeare, the tragedies and

romances. Selected plays from contemporary dramatists such as Webster, Tourneur, Middleton, Traister

331. Milton (3)

Life and works of John Milton in connection with the history of his times and the chief sources of his inspiration.

347. Advanced Writing Workshop (3)

Sustained work in writing and revising expository prose; classroom criticism in a workshop environment; grading by portfolio.

348. Theories in Writing (3)

Approaches to writing, ancient to modern; practice in composition. Theory and practice to help students develop strategies for writing effectively. Lotto

356. The Novel (3)

The novel as a literary form; selected novels from England, America, and the continent. Emphasis on a theme, period, or type.

360. Middle English Literature (3)

Major literary works of the Middle English period by authors other than Chaucer. Emphasis on Piers Plowman, the Gawain/ Pearl Poet, and the metrical romances. Hartung

362. The Renaissance (3)

English nondramatic literature in the 16th century and the stimulus of the Italian Renaissance and northern humanism. Readings in and class discussions of the works of the chief writers: Petrarch, Erasmus, More, Wyatt, Surrey, Lyly, Sidney, and Spenser.

364. The Seventeenth Century (3)

English literature of the 17th century, from Donne to Dryden. Traister

367. The Eighteenth Century (3)

Great British writers of the 18th century, beginning with the Restoration: Dryden, Pope, Swift, Defoe, Fielding, and Johnson and his circle. Fergus

369. British Romantic Literature (3)

Poetry and prose of Wordsworth, Coleridge, Byron, Shelley, and Keats within the contemporary, political, religious, and social context. Harson

371. British Victorian Literature (3)

Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social context. Bross

372. British Victorian Literature (3)

Major fiction of the Victorian era by such writers as Dickens, Eliot, Thackeray, and Hardy within historical, social, and aesthetic contexts. Mundhenk

373. Advanced Creative Writing Workshop (3)

Advance practice in and classroom criticism of creative writing done by students taking the course. Emphasis may vary: Fiction, Poetry, Creative Essay, Drama, etc. May be repeated for credit. Prerequisite: English 73, 174, or permission of Writing Minor Advisor.

375. Major Authors (1-3)

The works of one or more major literary figures studied in depth. May be repeated for credit as title varies.

376. Early American Literature (3)

Beginnings of American Literature, from Puritanism through the Enlightenment to early Romanticism: Taylor, Edwards, Franklin, Irving, Cooper. Gallagher

377. American Romanticism (3)

The chief American Romantics: Emerson, Thoreau, Whitman, Hawthorne, Melville, and Dickinson. The European and American philosophical, historical, and social

background as well as the aesthetic study of romantic masterpieces. Arbur, DeBellis

378. American Realism (3)

Theory and practice of realistic fiction from the Civil War to the early 20th century: Twain, Howells, James, Norris, Crane, Dreiser, and others. Frakes

379. Twentieth-Century American Literature (3)

American literature before World War II. Lectures and class discussion of major fiction and poetry. DeBellis, Mundhenk

380. Contemporary American Literature (3)

American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. DeBellis, Frakes

382. Themes in American Literature (3)

Intensive study of one topic in American literature. Readings from the colonial period to the present. May be repeated for credit as title varies.

383. Modernism and Post-Modernism in Fiction (3)

The 'anti-realistic' novel; time/space, point of view, narrative voice, structure as meaning. Kafka, Woolf, Beckett, Nabokov, Robbe-Grillet, Faulkner, Borges, Hawkes, Stein. Frakes

385. Twentieth-Century World Literature (3)

World English literature and continental literature before World War II. Lectures and class discussion of major fiction and poetry. Frakes

386. Contemporary World Literature (3)

World English literature and continental literature since World War II. Lectures and class discussions of new writers and of recent works by established writers. Frakes, Fifer

387. Film History and Criticism (3)

Study of certain films, dealing with a particular genre, director, theory, period or theme. May be repeated for credit as title varies. Doty

388. Independent Study (1-3)

Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of department chairperson.

391. Special Topics (1-3)

A topic, genre, or approach in literature or writing not covered in other courses.

Graduate Courses in English

The following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate English majors who are planning to go on to graduate school in English and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year.

400. Supervised Teaching

421. History of the English Language (3)

The phonology, grammar, and lexicon of English from the beginnings to the present. Vickrey

423. Old English (3)

Old English language and literature. Vickrey

424. Beowulf (3)

The Beowulf poem and some of the pertinent scholarship. Prerequisite: English 423 or its equivalent. Vickrey

427. Chaucer (3)

Chaucer's language. *The Canterbury Tales*. Readings, reports, and discussions. Hartung

428. Chaucer (3)

Chaucer's Minor Poems, *Troilus* and other pre-Canterbury period works. The 15th-century 'Chaucerians.' Readings, reports, and discussions. Hartung

429. Middle English Metrical Romances (3)

Non-Arthurian verse romances. Introduction to paleography. Folk and court backgrounds. Narrative theory. Hartung

431. Arthurian Literature of the Middle Ages (3)

Arthurian literature from its Celtic Beginnings to Malory's *Morte D'Arthur*. Hartung

Courses numbered 433-477 are period courses in English and American literature. Offerings under each course number vary from year to year, and a course may be repeated for credit as the title varies. Titles listed under each graduate number are those likely to be offered in 1993-1996.

433. Middle English Literature (3)

The Medieval Origins of English Drama: Study of several medieval plays (*Everyman*, *Second Shepherd's Play*, and selected plays in one of the English mystery play cycles). Consideration also of the "dramatic techniques" of Chaucer as a precursor to the drama that was to flourish centuries later. Beidler

The Medieval Comic Tale: Study of several English, French and Italian tales with emphasis on French fabliaux, Boccaccio's *Decameron*, and three or four of Chaucer's *Canterbury Tales*. Beidler

439. Sixteenth-Century British Literature (3)

Renaissance Love Poetry: Study of the sixteenth-century sonnet sequence, epyllion, and Ovidian lyric. Works by Wyatt, Surrey, Marlowe, Sidney, Fulke Greville, Spenser, and Shakespeare. Traister

City and Court under Elizabeth and James: Study of how the City (London) and the Court under each monarch are represented in contemporary texts—in drama, poetry, letters, sermons, and prose tracts. Traister

441. Seventeenth-Century British Literature (3)

Literature of the English Revolution: Examination of the causes, circumstances, and consequences of the English Revolution as expressed from 1640-1670. Readings in: Hobbes, Harrington, Lilburne, Milton, Marvell, and Bunyan. Hawkes

Theology and Interpretation in the Renaissance: Drawing on the hermeneutics of Luther and Calvin, the course will focus on how English writers of the sixteenth and seventeenth centuries elaborated a distinctively Protestant mode of signification. Writers studied will include Jonson, Donne, Herbert, Traherne, Browne, and Burton. Hawkes

443. Eighteenth-Century British Literature (3)

Frances Burney and Jane Austen: Major novels of Burney and the novels and juvenilia of Austen in their social and literary contexts. Examination of what it meant to be a professional woman writer between 1770-1820. Fergus

Literature in the Marketplace: Eighteenth-Century British Fiction: Study of the eighteenth-century marketplace through examining "canonical" works in relation to the print culture that engendered and then imitated them. Sources for this examination include periodical literature, children's books, "minor" fiction, and booksellers' records. Fergus

445. Nineteenth-Century British Literature (3)

Romanticism and the Gothic: Tales of terror and suspense (in fiction, poetry, and drama), from eighteenth-century origins through the psychological gothic in the nineteenth century. Emphasis on developments in the Romantic period. Harson

The Victorian Novel and Poststructural Theory: Intensive study of three or four Victorian novels, by writers such as Dickens, Eliot, Bronte, and Thackeray, through the lens of Feminist, Marxist, Psychoanalytical, Deconstructive, and Cultural theory. Mundhenk

The Problem of Knowledge in the Victorian Age: Given the new kinds of knowledge emerging in their time, such writers as Dickens, Carlyle, Mill, Marx, Eliot, Tennyson, Browning, Arnold, Ruskin, and Newman had to ponder the question: What notions—religious doctrines, for example, or scientific observations—should be considered “knowledge”? Bross

449. Twentieth-Century British Literature (3)

James Joyce: Close examination of the works of James Joyce, with special attention to style, narrative voices, and thematic complexity. Frakes

Modern British Fiction: Concentration on one or more major figures: Joyce, Conrad, Shaw, Forster, Woolf, Lawrence, Beckett. Revitalized “New Critical” approaches. Frakes

471. Early American Literature (3)

Benjamin Franklin and the American Character: In-depth study of Franklin's work, life, and career, as well as study of his influence and reputation through works written about him—some loving, some vicious—from John Adams to John Updike. Gallagher

Early American Literature: A broad survey of literature from Columbus to the end of the eighteenth century, focusing on important writers, geographical and cultural diversity, and diverse literary forms (history, sermon, poetry, autobiography, novel, travel narrative, political essay). Gallagher

473. American Romanticism (3)

Emerson, Dickinson, Frost: Emerson's philosophy, literary theory, and poetry as the context in which we consider the poetry of Dickinson and Frost. Arbur

Literary Watersheds: *Moby Dick*, *Uncle Tom's Cabin*, *Walden*, and *Leaves of Grass* not only transformed but invented our national literature. Focus on close reading, critical reputation, and contemporary approaches to these four works. Arbur

475. American Realism (3)

Henry James: Close examination of the works of The Master: short stories, novellas, and major novels. Varied critical approaches. Frakes

Literary Realism and Naturalism: Selected fiction by one or more of the following pioneers in American literary realism and literary naturalism: Henry James, Mark Twain, Stephen Crane, William Dean Howells, Frank Norris, and Theodore Dreiser. Frakes

477. Modern American Literature (3)

Ernest Hemingway: Heightened “New Critical” approaches to the short stories and major novels of Ernest Hemingway. Frakes

Modern American Fiction: Heightened “New Critical” approaches to one or more major fiction writers from 1900 to 1950: Hemingway, Faulkner, Fitzgerald, Dos Passos, West, Porter. Frakes

Modern Southern Writers: Major Southern writers since 1920 from all regions—Styron, O'Connor, Williams, Faulkner, Welty, Percy, Porter, Ransom, Tate, and Warren. All genres, and some sub-genres like “Southern Gothic,” will be studied, and social and philosophical influences will be explored. DeBellis

Contemporary American Poetry: Poets from the 1960's to the present. Such poets as Creeley, Ginsberg, Levine, Rich, Plath, Lorde, Lowell, Kinnell, Baraka. Fifer

Modern American Drama: Drama from the 1920's to the 1960's. Such playwrights as Rice, Wilder, O'Neill, Williams, Hellman, Miller, Albee. Fifer

481. Theory and Criticism (3)

Theory and practice of criticism in the study of film, literature, and composition. Offerings vary from year to year and course may be repeated for credit as the title varies. Titles below are those likely to be offered 1993-1996.

Theories of Authorship in Literature and Film: Material from Western Romanticism through theorists such as Derrida, Barthes, and Foucault. Focus on film *auteurism* and structuralist, post-structuralist, and feminist, marxist, and gay/lesbian challenges to and reconceptualization of notions of authorship. Doty

The Ideology of the Aesthetic: Consideration of the aesthetic impulse and its relationship to rhetoric and literary criticism. Readings from Lentricchia, Eagleton, the Frankfurt School, Jameson, Burke, Bakhtin, and Bourdieu. Lotto

Feminist Theory and Speculative Fiction: How woman's concerns find expression in non-realistic fiction by Le Guin, Russ, McKillip, Tepper, Elgin, Slonczewski, and Tiptree. Collateral readings in feminist theory. Arbur

Advanced Critical Theory: Study of several important and influential recent theoretical texts. Emphasis on “pure” rather than “applied” theory: readings will include Macherey, Derrida, Lacan, Kristeva, and Jameson. Hawkes

485. Teaching of College English (3)

History, theory, and practice of teaching the freshman composition course. Required of all new teaching assistants in the department of English. May be rostered by others only with consent of the department chairperson.

491. Special Topics (1-3)

A topic, genre, or approach in literature or writing not covered in other courses. May be repeated for credit as title varies. Prerequisite: consent of the graduate program coordinator.

493. Graduate Seminar (3)

Intensive study of the works of one or more authors, or of a type of literature. May be repeated for credit as title varies.

495. Independent Study (3)

Individually supervised course in an area of literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of the graduate program coordinator.

Environmental Writing

See Listings under Journalism and Communication

Finance

Professor. Carl R. Beidleman, Ph.D. (Pennsylvania), *DuBois Professor of Finance*.

Associate professors. Stephen G. Buell, Ph.D. (Lehigh), *chairperson*; James A. Greenleaf, Ph.D. (N.Y.U.); Stephen F. Thode, D.B.A. (Indiana); Geraldo M. Vasconcellos, Ph.D. (Univ. of Illinois).

Assistant professors. Richard J. Kish, Ph.D. (Univ. of Florida); Mary S. Schranz, Ph.D. (Washington University); C. Sloan Swindle, Ph.D. (University of Florida).

Adjunct professors. David L. Muething, Ph.D. (M.I.T.); Samuel C. Weaver, Ph.D. (Lehigh).

The finance major offered in the College of Business and

Economics requires fifteen credit hours beyond the core listed on page 33. Each finance major selects either the Business Finance or Financial Economics track.

Business Finance

required courses:

Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)

plus two of the following:

Fin 324 Security Analysis (3)
Fin 330 Financial Flows and Markets (3)
Fin 331 Bank Management (3)
Fin 333 Multinational Business Finance (3)
Fin 334 Speculative Markets (3)
Fin 335 Advanced Financial Modeling (3)
Fin 336 Real Estate Finance (3)

plus one additional 300-level finance or finance/economics course.

Financial Economics

required courses:

Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)

plus two of the following:

Fin 332 Monetary-Fiscal Policy (3)
Fin 340 International Finance (3)
Fin 353 Public Finance: Federal (3)
Fin 354 Public Finance: State and Local (3)

plus one additional 300-level finance or finance/economics course.

For Advanced Undergraduates and Graduates

225. Business Finance (3) fall, spring

Introductory corporation finance, which stresses a managerial approach to asset management and capital structure. Financial policies regarding the acquisition of funds and their allocation among competing assets within the firm. Prerequisites: Eco 145, Eco 105, Math 41 and 44, Acct 51. Buell, Schranz

240. Introduction to Real Estate (3) spring

A survey of the four broad perspectives of real estate: legal, economic, financial, and business. Topics include: legal and physical rights to real estate; the nature and operation of real estate markets; valuation and appraisal of real estate; financing alternatives; and the real estate development process. Prerequisite: Fin 225 or permission of instructor.

323. Investments (3) fall, spring

The nature of risk and the form of returns to financial assets. Investor objectives, attitudes, and constraints are considered within the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics, and portfolio management. Prerequisite: Fin 225. Schranz, Swindle

324. Security Analysis (3) fall

Factors influencing the value of financial securities: earnings forecasts and expectations, uncertainty, required returns, supply and demand for securities and funds, and investor attitudes. Implications of market factors, technical approaches, timing, and screening. Prerequisites: Acct 111 and Fin 323. Not ordinarily open to CBE graduate students. Beidleman

328. Corporate Financial Policy (3) fall, spring

Advanced corporate finance; capital budgeting, working capital management, leasing, mergers, and financing. Case studies and complex problems. Prerequisite: Fin 225. Not ordinarily open to CBE graduate students. Thode, Kish

330. Financial Flows and Markets (3) fall

Functions and portfolios of financial intermediaries. Sectoral demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulation on financial intermediaries and

markets, and current developments in the financial system. Prerequisites: Eco 229 and Fin 225. Not ordinarily open to CBE graduate students. Swindle, Schranz, Vasconcellos

331. Bank Management (3) spring

Management of bank assets and liabilities within U.S. system's legal and economic constraints. Bank Management Simulator is used to examine relationships between asset, liability, and profitability decisions. Prerequisites: Eco 229 and Fin 225 senior standing or consent of instructor. Not ordinarily open to CBE graduate students. Schranz, Vasconcellos

332. (Eco 332) Monetary-Fiscal Policy (3)

Monetary, credit and fiscal policies of government and central banks, with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 229.

333. Multinational Business Finance (3) fall, spring

Issues that underlie the investment, financing, and dividend decisions of multinational firms, Current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: Fin 328. Not ordinarily open to CBE graduate students. Beidleman, Vasconcellos

334. Derivative Securities Markets (Options, Futures, etc.) (3) spring

Theoretical and practical aspects of various instruments and markets that involve financial derivative securities (options, futures, swaps, CMO's, etc.). Emphasis on applications to corporation finance and portfolio management. Prerequisite: Fin. 323.

335. Advanced Financial Modeling (3) fall

Modeling of complex financial decisions including bond refunding, security valuation, option pricing, currency swaps, and leasing. Utilizes the problem-solving capabilities of modern microcomputer spreadsheets. Prerequisites: Fin 323 and Fin 328 or consent of instructor. Not ordinarily open to CBE graduate students. Buell, Thode

336. Real Estate Finance (3) fall

An advanced survey of modern residential and commercial real estate financing techniques from the perspectives of the borrower and the lender. Topics include: the principles of financing decisions; financing methods and techniques, institutional sources of funds for real estate, and real estate financing decision-making. The course includes lectures, demonstrations, spreadsheet software exercises, and guest speakers. Prerequisite: Fin 225.

340. (Eco 340) International Finance (3)

Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 229. Callahan, Gunter

353. (Eco 353) Public Economics and Government Finance: Federal (3)

A course dealing with the expenditures and revenues of the Federal government. Major topics include public choice theory, benefit-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisites: Eco 1 or Eco 11 and 12.

354. (Eco 354) Public Economics and Government Finance: State and Local (3)

A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisites: Eco 1 or Eco 11 and 12.

371. Directed Readings (3)

Readings in various fields of finance designed for the student with a special interest in some field of finance not

covered in scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

372. Special Topics (1-3)

Special problems and issues in finance for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of department chairperson. May be repeated.

For Graduate Students

411. Financial Management (3) fall

Introduction to financial management, with consideration of advanced topics, with respect to: risk, valuation, capital structure, dividends, capital budgeting, and working capital management. Prerequisites: Eco 408 (or concurrently) and Acct 403. Kish, Weaver, Thode

430. Investments and Portfolio Management (3) fall
Investment instruments and institutions, historical performance, technical analysis, risk and diversification, portfolio theory. Prerequisite: Fin 411. Greenleaf, Schranz

431. Advanced Investment and Portfolio Analysis (3) spring
Theoretical and empirical examination of recent developments in portfolio theory. Prerequisite: Fin 430. Muething

432. Financial Management of Financial Institutions (3) fall
Asset and liability management of commercial banks, savings and loan associations, life insurance companies, and pension funds. Short and long run responses to changes in economic conditions, interest rates, and regulations. Prerequisite: Fin 411. Vasconcellos

433. (Eco 433) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Beidleman, Buell

434. Cases in Financial Management (3)
Integration of multiple topics in corporation finance through analysis of complex cases, including: capital budgeting, working capital management, leasing, mergers, and financing. Prerequisite: Fin 411. Thode

436. International Financial Management (3)
Financial management of multinational firms. Consideration of problems arising from diversity of currencies, investment opportunities, risk, and international capital markets. Case studies. Prerequisite: Fin 411. Beidleman, Vasconcellos

444. (Eco 444) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes

447. (Eco 447) Capital and Interest Theory (3) alternate years
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance.

449. (Eco 449) Public Finance (3) spring, even-numbered years
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

451. Quantitative Financial Models (3) alternate years
Relationship of quantitative models to financial theory and applications. Capital budgeting, portfolio selection, security

evaluation, cash management, inventory policy and credit analysis. Prerequisite: Fin 411. Muething

456. Options and Financial Futures (3) spring
Examination of the options pricing model and its implications for options management and equity pricing. Theory and applications for hedging and speculation. Emphasis is placed on trading of options on debt, equity, stock indices and futures. Financial futures and index futures are also examined for their contributions to individual portfolio management. Prerequisite: Finance 430. Greenleaf

457. (Eco 457) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: Eco/Fin 444 or equivalent. Innes, Callahan

459. (Eco 459) International Financial Economics (3)
Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management. Callahan, Gunter

471. Directed Readings (1-3)
Readings in finance not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

472. Special Topics (1-3)
Problems and issues in finance for which no regularly scheduled graduate course work exists. When offered as group study, coverage varies according to interest in finance. Prerequisite: consent of the department chairperson. May be repeated.

Fine Arts

See listings under Art and Architecture.

Five-Year Programs

There is a number of ways in which students can obtain two degrees in five years of study. See listings under Arts-Engineering; Arts-Master of Business Administration; Civil Engineering and Geological Sciences; Electrical Engineering and Engineering Physics; and Engineering-Master of Business Administration.

Foreign Culture And Civilization

See listings under Modern Foreign Languages.

Foreign Literature

See listings under Classics and under Modern Foreign Languages.

French

See listings under Modern Foreign Languages.

Fundamental Sciences

Kenneth N. Sawyers, Ph.D. (Brown University), *director*,
associate dean of the College of Engineering and Applied Science.

The curriculum in fundamental sciences is designed to enable students to achieve a breadth of academic background in the fields of modern science and at the same time, through an option, to master the discipline of one of them, approximately to the level of a minimum bachelor's program. The options and electives provide sufficient flexibility to enable a student to prepare for employment in industry or government for graduate study in a field, or for teaching mathematics or science at the secondary level.

Fundamental science students are required to concentrate in a major. Students can organize acceptable programs including the substantive course elements related to any one among several areas such as chemistry, physics and mathematics, biology, earth and space science, science of living systems, materials, computer science, and architecture, or meaningful combinations of any two.

The freshman year is identical with that of all students in the College of Engineering and Applied Science. The General Studies requirements of the college must also be satisfied. The discipline of a field will be provided by the inclusion of at least fifteen semester hours or from a combination that constitutes the core of one of the combination fields. Examples of these combination majors include: biochemistry, geophysics, bioengineering, applied mathematics, biophysics, and computer science. Students pursuing double concentrations may, with the approval of their adviser, substitute for one of the science courses of the sophomore year a basic course in the area of concentration.

The details of the student's program are worked out by the student with the advice of the curriculum adviser, and with the approval of the department chairperson concerned with the fields of concentration.

Recommended Sequence of Courses

freshman engineering year (see page 34)

sophomore year, first semester (15 credits)

EES 31, 32	Introduction to Environmental and Organic Biology and Laboratory (4) or
EES 21	Introduction to Earth Materials and Processes and Laboratory (4)
Chm 51, 53	Organic Chemistry and Laboratory (4)
Math 23	Analytic Geometry and Calculus III (4)
Eco 11 or 12	Microeconomics or Macroeconomics (3)

sophomore year, second semester (17 credits)

	major subject (3)
	approved elective (3)
Math 205	Linear Methods (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
	HSS elective (3)

junior year, first semester (16 credit hours)

EES 21	Introduction to Earth Materials and Processes and Laboratory (4) or
EES 31, 32	Introduction to Environmental/Organismal Biology and Laboratory (4)

Psyc 1	Introduction to Psychology (4)
Math 231	Probability and Statistics (3)
	major (3)
	HSS elective (3)

junior year, second semester (15 credit hours)

	approved electives (6)
	major (6)
	elective (3)

senior year, first semester (18 credit hours)

	approved electives (6)
	major (6)
	HSS elective (3)
	free elective (3)

senior year, second semester (18 credits)

Phil 128	Philosophy of Science (3)
	approved elective (3)
	major (6)
	HSS elective (3)
	free elective (3)

Geophysics

Kenneth P. Kodama, professor of geophysics, *director*.

Geophysics is the branch of the earth sciences in which physical principles are used to understand the subsurface geology and history of the earth. Geophysical methods are important both in the search for energy and mineral resources the delineation of groundwater supplies and the sources of their pollution, and understanding the structure of environmental systems. On a global scale geophysics has allowed us to unravel the history of continental drift and to better understand the plate tectonic model. The program is designed to provide the background needed for graduate work in geophysics or the preparation for employment in the petroleum industry or geophysical consulting firms.

Major Requirements for a B.S. in Geophysics (125-126 credit hours)

college and university requirements (28 credits)

Arts and Science	Choice and Decisions (1)
1	
Engl 1	Composition and Literature (3)
Engl 2, 10, 14, 16	Composition & Literature (3)
FS 90	College Seminar (3)

distributional electives

Social Sciences and Humanities (18)

free elective (9 credits)

major program (88-89 credit hours)

mathematics (18 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry & Calculus II (4)
Math 23	Analytic Geometry & Calculus III (4)
Math 205	Linear Methods (3)
Math 322	Methods of Applied Analysis (3)

collateral sciences (5 credit hours)

Chm 21, 22	Introductory Chemical Principles and Lab (4, 1)
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physics (19 credit hours)

Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)

Phys 215 Classical Mechanics I (3)

earth science (34-35 credit hours)

EES 21	Introduction to Earth Materials and Processes (4)
EES 113	Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
EES 133	Introduction to Mineralogy (3)
EES 135	Introduction to Lithology and Petrology (3)
EES 213	Sedimentology and Stratigraphy (3)
EES 223	Structural Geology (3)
EES 292	Research Seminar (1)
EES 373	Geochemical Thermodynamics (3)
EES 301	Introduction to Geophysics (3)
EES 302	Solid Earth Geophysics (3)
	Minerals (3)
EES 122	Introduction to Plate Tectonics (3), or
EES 326	Geologic Evolution of North America (3)
EES 291	Earth and Environmental Science Research

approved professional electives (12 credit hours)

Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. Examples of coherent groups of courses are given below. Other courses may be used to fulfill this requirement subject to the approval of the undergraduate adviser.

Emphasis on Environmental Geophysics

EES 376	Geochemistry of Natural Waters
EES 306	Geophysical Field Techniques
EES 309	Environmental Magnetism
EES 316	Hydrogeology
EES 341	Field Geology
EES 307	Case Studies in Engineering Geology

Emphasis on Solid Earth Geophysics

EES 134	Introduction to Optical Mineralogy and Crystallography
EES 334	Igneous and Metamorphic Petrology
EES 374	Isotope Geochemistry and Geochronology
EES 405	Paleomagnetism

*Additional mathematics and physics courses.

Emphasis on Geophysical Signal Processing

EES 308	Seismic Data Processing
EES 407	Seismology and either
ECE 81	Principles of Electrical Engineering
ECE 108	Signals and Systems
ECE 343	Digital Signal Processing, or
Phys 190	Electronics
Phys 260	Laboratory techniques

*The following 4 mathematics and physics courses are recommended for the solid earth geophysics and tectonophysics areas of emphasis.

Math 208	Complex variables
Math 320	Ordinary Differential Equations
Math 323	Methods of Applied Analysis II
Phys 216	Classical Mechanics II

German

See listings under Modern Foreign Languages.

Government

Professors. Frank T. Colon, Ph.D. (Pittsburgh), *chairperson*; Donald D. Barry, Ph.D. (Syracuse), *University Professor*; Richard K. Matthews, Ph.D. (Toronto); Edward P. Morgan, Ph.D. (Brandeis); Laura Katz Olson, Ph.D. (Colorado); Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany).
Assistant professors. Albert H. Wurth Jr., Ph.D. (North Carolina); Frank L. Davis, Ph.D. (North Carolina); Hannah Stewart-Gambino, Ph.D. (Duke).
Adjunct professors. Candace K. Briggs, M.A. (East Stroudsburg); John Martin, M.A. (Rutgers).

The major in government is designed to promote understanding of political ideas, institutions and processes and to develop skills in analyzing and evaluating political problems.

A balanced program within the discipline, one that exposes the student to various areas of inquiry in American institutions and political processes as well as in the comparative and philosophical perspectives of political analysis, has been the way in which the goals of the major program generally have been achieved. While the major program outlined below will prove adequate for most student needs, it may be that because of some special factors such as late transfer or unusual interests and/or abilities the outlined program does not accommodate some students. In that case the students may, in consultation with their adviser, develop a major program that in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in the government department is designated by the department. The adviser consults with the student and approves the major program. The adviser attempts to help the student relate courses offered by the department to the student's educational goals. The adviser also may act as a resource for the students, and may suggest courses in other disciplines, language courses, and courses in research techniques that may be of benefit.

A variety of experiential opportunities are available to undergraduates majoring in government. The department, for example, offers a Community Politics Internship every semester that includes opportunities for internship placements in either local government, private agencies or law offices. Students are also encouraged to apply for off-campus, internship opportunities, e.g., American University's Washington Semester Program.

Completion of the government major is considered suitable training for the undergraduate who wishes to go on to law school, to become a social science teacher, or to work as a governmental official, party or civic leader, public affairs commentator, or staff member of a government research bureau. In addition, the business sector continues to provide opportunities in areas such as banking, insurance, and marketing for bachelor of arts graduates with training in the social sciences. Graduate study is advisable for students contemplating certain careers: college teaching, research, or public management, for example.

The three core courses are required. Individual exceptions may be made, for good reasons, by the major adviser with the approval of the department chairman.

Major Requirements

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)
Govt 100	Introduction to Political Thought (3) or
Govt 101	Ancient Political Heritage (3) or
Govt 102	Modern Political Heritage (3)

electives

Eight elective courses with at least two courses from each of the following two fields:

<i>American politics, public law and interdisciplinary</i>	
Govt 111	The Politics of the Environment (3)

Govt 115	Technology As Politics (3)
Govt 174	Political Parties and Elections (3)
Govt 177	Urban Politics (3)
Govt 179	The Politics of Women (3)
Govt 302	Comparative State Politics (3)
Govt 306	Public Policy Process (3)
Govt 317	The American Presidency (3)
Govt 327	Socialization and the Political System (3)
Govt 329	Propaganda and American Politics (3)
Govt 330	Politics of the 1960's (3)
Govt 331	Community Politics Internship (3)
Govt 333	The Social Psychology of Politics (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
Govt 359	U.S. Congress (3)
Govt 360	Public Administration (3)

Political theory and comparative politics

Govt 100	Introduction to Political Thought (3)
Govt 101	Ancient Political Heritage (3)
Govt 102	Modern Political Heritage (3)
Govt 125	International Political Economy (3)
Govt 132	An Introduction to Canada (3)
Govt 301	Current Political Controversies (3)
Govt 318	Seminar in Post Soviet Politics (3)
Govt 321	Research in Political Science (3)
Govt 322	Politics of Developing Nations (3)
Govt 335	Latin America Political Systems (3)
Govt 336	U.S. Foreign Policy and Latin America (3)
Govt 337	Religion and Politics in Latin America (3)
Govt 361	Soviet and Post Soviet Politics (3)
Govt 364	Issues in Contemporary Political Philosophy (3)
Govt 367	American Political Thought (3)
Govt 368	Political Economy (3)

Government Minor

The minor consists of three core courses listed above (Govt 1, Govt 3, and Govt 100 or 101 or 102) plus any two other government courses.

Public Administration Minor

The minor consists of Govt 360 plus four other courses chosen in consultation with the adviser for a total of fifteen credit hours.

Undergraduate Courses

1. American Political System (3) fall-spring
Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights.

3. Comparative Politics (3) fall-spring
The political systems of foreign countries; approaches to the study of comparative politics.

100. Introduction to Political Thought (3) fall-spring
Some of the most significant ancient and modern political theorists: Plato, Aristotle, Machiavelli, Hobbes, Marx, and others. Matthews

101. Ancient Political Heritage (3)
Important political thinkers from the pre-Socratics to early, modern political theorists like Machiavelli. Matthews

102. Modern Political Heritage (3) fall-spring
Begins where Govt 101 ends: from early, modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marcuse, Habermas). Matthews

111. The Politics of the Environment (3)

A survey of the major environmental, resource, energy and population problems of modern society, focusing on the United States. The politics of man's relationship with nature, the political problems of ecological scarcity and public goods, and the response of the American political system to environmental issues. Wurth

115. Technology as Politics (3)

Relationship of technology and technological change with politics and public policy. Review of theories of political significance of technology, including technological determinism, technology assessment, technological progress and appropriate technology. Specific issues in technology with emphasis on U.S. Wurth

125. (IR 125) International Political Economy (3)

Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy in its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1 or 11 or 12; IR 10. Moon, Barkey

132. (Eco., Hist., I.R.) An Introduction to Canada (3)

An interdisciplinary, team-taught course focusing on history, politics, economics and international relations. Topics covered will include Canada's historical development, recent politics and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States.

174. Political Parties and Elections (3)

Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections. Colon

177. Urban Politics (3)

The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal. Colon

179. (WS 179) The Politics of Women (3)

Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson

For Advanced

Undergraduates and Graduate Students

301. Current Political Controversies (3)

Selected topical policy issues and alternative approaches to understanding them. Including problems facing the current President, controversies in Eastern Europe, reproductive technologies, and crises in the American political economy.

302. Comparative State Politics (3)

Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government. Colon

306. Public Policy Process (3)

Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson

313. Teaching Government (3)

Contemporary issues in the teaching of social studies in public and private schools, including those government decisions that affect the educational environment. The course focuses attention on a specific issue such as urban problems, comparative political systems, ideologies and American political institutions and processes. Designed primarily for secondary school teachers.

314. Workshop in Teaching Government (3)

Individual research projects contemporary issues and discussion of proposals for curriculum revisions in the public and private schools. Outside speakers will be invited to attend workshop sessions. Must be taken concurrently with Govt 313 when courses are offered together.

317. The American Presidency (3)

Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Prerequisite: Govt 1. Olson

318. Seminar in Post Soviet Politics (3)

Analysis of selected issues in the politics of the former USSR. Prerequisites: Government 361 or consent of the instructor. Barry

321. Research in Political Science (3)

Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; practical and political considerations in the use of opinion polls. Prerequisite: Consent of the instructor. Davis

322. Politics of Developing Nations (3)

Theories of political development in non-Western areas; modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology. Prerequisite: Govt 3. Stewart-Gambino

327. Socialization and the Political System (3)

The social ideological and economic foundations of American politics. Emphasis on supporting institutions—family, schools, and workplace—and processes that foster political attitudes and behavioral patterns. Morgan

329. Propaganda and American Politics (3)

Seminar on the role of propaganda with emphasis on mass culture, television, and the relationship between government and mass media. U.S. foreign and domestic policy analyzed using critical propaganda theories. Prerequisite: junior standing. Morgan

330. Politics of the 1960's (3)

The lessons and legacies of 1960's social and political movements, including civil rights, black power, the New Left, campus protests, the Vietnam war and antiwar movement, the counterculture, women's and ecology movements. Prerequisite: junior standing. Morgan

331. Community Politics Internship (3)

Integrated fieldwork and academic study. Seminar, research paper, and journal; internship with government and social service agencies, political groups, elected officials, and law offices. May be repeated for credit. Prerequisite: consent of the department chairperson.

333. (SSP 333) The Social Psychology of Politics (3)

Political behavior viewed from a psychological and social psychological perspective. Rosenwein

335. Latin American Political Systems (3)

The effects on Latin American cultures and political systems of the Spanish colonial period; democratic, authoritarian, and revolutionary paths to contemporary development; and political prospects for the future are some of the major themes discussed. Prerequisite: Govt 3. Stewart-Gambino

336. U.S. Foreign Policy and Latin America (3)

United States' historical relationship with Latin America. Topics of particular salience to current U.S.-Latin America relations, and topics of current relevance. Stewart-Gambino

337. Religion and Politics in Latin America (3)

Major indigenous religious structures, the prominent role of the Catholic Church in Latin America, and the recent implosion of Protestant/Pentecostal sects. Stewart-Gambino

351. Constitutional Law (3) fall

The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, distribution and scope of governmental powers, and economic regulation in a federal system. Detailed consideration of judicial policy decision-making processes. Whitcomb

352. Civil Rights (3) spring

A study of constitutional development in political and civil rights. Freedom of speech and of the press, religious freedom, due process of law and equal protection of the laws. Detailed consideration of constitutional issues concerning criminal procedure and racial discrimination. Whitcomb

354. Administrative Law (3)

The authority, procedures, and methods used by executive agencies in the administration of public policy. Analysis of the general problem of adjusting the administrative process to traditional constitutional principles. Barry

359. U.S. Congress (3)

The origins and development of Congress, formal and informal power of legislation and oversight. Party leadership and committees, House and Senate differences, and Congressional relations with the President, the bureaucracy and the Supreme Court. Prerequisite: Govt 1. Davis

360. Public Administration (3)

The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon

361. Soviet and Post-Soviet Politics (3)

The political systems of the former USSR. The evolution of the Soviet system; the Gorbachev era; the search for new political arrangements. While all of the former Soviet republics will be open for examination in this course, emphasis in the post-Gorbachev period will be placed on the Russian Federation. Barry

364. Issues in Contemporary Political Philosophy (3)

Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with the consent of the department chairperson. Matthews

367. American Political Thought (3)

A critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. Matthews

368. Political Economy (3)

Relationship of democratic politics to government and market, and of significance of economic power in the American polity. Economic rationale for the place of the market and economic institutions in polity. Comparison of economic approaches to public policy and organization, like public goods, market failure and collective action. Group mobilization and conflict, non-decisions, and symbolic action. Wurth

371. Readings (1-3)

Readings in political science assigned to properly qualified students in consideration of their special interest in particular political institutions and practices. Prerequisite: consent of the departmental chairperson.

372. Readings (1-3)

Continuation of Govt 371. Prerequisite: consent of the department chairperson.

381, 382. Special Topics (1-3)

A seminar on a topic of special interest in a particular

political institution process, or policy. Prerequisite: consent of the department chairperson.

For Graduate Students

The department of government offers a graduate program leading to the master of arts degree. The applicant for admission is required to demonstrate adequate undergraduate preparation, and may under certain circumstances be asked to submit Graduate Record Examination results.

Master of Arts

The master of arts in government is a thirty-credit-hour program that can be accomplished in twelve months by full-time students. A comprehensive examination is required. The student may take twenty-four hours of course work and six hours of thesis or may take all thirty credit hours in course work. A graduate-level course in research methods is required of all candidates for the master of arts degree.

The master of arts program is intended for the student with liberal arts or natural science preparation who has a professional interest in government. The master of arts may be a preparatory step toward doctoral work at another institution or a final degree preparatory for teaching in junior and community colleges or research positions in governmental, institutional or industrial settings.

Graduate Courses

405. The Budgetary Process (3)

The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation. Davis

407. American Constitutional Development (3)

The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, institutional aspects of separation of powers and federalism, economic regulation in a federal system, and political and civil rights. Detailed consideration of judicial policy-making processes and judicial biography. Whitecomb

411. The Legal Foundations of Public Administration (3)

The authority, procedures, and methods used by executive agencies in the administration of public policy and the general problem of adjusting the administrative process to traditional constitutional and legal principles. Barry

413. Modern Political Philosophy (3)

A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Matthews

415. State and Local Government (3)

Comparative state government, urban politics, intergovernmental relations, regional and local government. Colon

416. American Environmental Policy (3)

Formation, implementation and impact of environmental policies in the U.S. An examination of the scope of environmental problems, the development of environment as an issue, the role of interest groups and public opinion, the policy-making process, and the various approaches to implementing environmental policy. Special attention to current issues and administrative approaches and to the distinctive character of environmental protection as a political issue. Wurth

419. Theoretical Issues in American Politics (3)

American contributions to main currents in political philosophy from colonial times to present. Matthews

421. Research Methods (3)

Research approaches, design techniques, statistical and non-statistical analysis, and computer applications. Davis

431. Public Management (3)

The study of bureaucracy and problems of public and nonprofit organization and management; executive leadership; personnel management systems and regulatory administration. Colon

432. Public Policy Process (3)

Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environmental, energy, poverty, health, and taxation. May be repeated for credit. Olson

434. Internship (3)

Internship in private or public agency. May be repeated for credit.

451. Comparative Politics (3)

Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.

463. Methods of Urban Policy Analysis (3)

Analysis of selected topics in urban or state/local policy. Applied research projects include computer-based statistical analysis. Prerequisite: Govt 421 or consent of the department chairperson. Morgan

471. Seminar in Teaching Government (3)

Theories and techniques of instruction, learning, evaluation, instructional design and innovation in the teaching of government. Prerequisite: permission of the department chairperson.

481. Special Topics (1-3)

Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.

482. Special Topics (1-3)

Continuation of Govt 481.

Greek

See listings under Classics.

Hebrew

Modern Hebrew is taught in the Department of Modern Foreign Languages. Biblical Hebrew is taught in the Department of Religion Studies.

History

Professors. Roger D. Simon, Ph.D. (Wisconsin), *chairperson*; Michael G. Baylor, Ph.D. (Stanford); Joseph A. Dowling, Ph.D. (N.Y.U.), *distinguished professor*; Ian P.H. Duffy, D.Phil. (Oxford, England); John H. Ellis, Ph.D. (Tulane); Steven L. Goldman, Ph.D. (Boston), *Andrew W. Mellon Distinguished Professor in the Humanities*; Tom F. Peters, Dr. Sc. (Swiss Federal Institute of Technology, ETH Zurich); C. Robert Phillips, Ph.D. (Brown), *Classics and Ancient History*; James S. Saeger, Ph.D. (Ohio State); William G. Shade, Ph.D. (Wayne State); C. Leon Tipton, Ph.D. (Southern California). **Associate professors.** Stephen H. Cutcliffe, Ph.D. (Lehigh), *History and STS*; John K. Smith, Ph.D. (Delaware). **Assistant professor.** Gail A. Cooper, Ph.D. (U.C., Santa Barbara). **Adjunct professors.** Curtis Keim, Ph.D. (Indiana); Winfred Kohls, Ph.D. (Berkeley).

Adjunct lecturer. Gerald R. Bastoni, M.A. (Lehigh).

The History major introduces students to the study of the causes and consequences of change through an examination of political, economic, social, cultural, and intellectual developments and institutions over time. The department's goal is to train its majors to think critically about the events and forces which have shaped the modern world, to analyze and interpret sources and evidence, and to view issues from a variety of perspectives. Those skills have served students well in a wide range of careers. Lehigh History majors have frequently gone on to law school or to work in various areas of education, journalism and public affairs, but the majority have pursued a wide range of business occupations. The major also provides an excellent basis for graduate training in a wide range of public policy fields.

To assure diversity and breadth, majors are asked to take courses in three cultural areas. The writing intensive requirement must be filled by a course in the History department.

The department offers a program of independent research under the direction of an individual faculty member (History 391, 392). A maximum of six credits may be used toward this project. Normally students pursue their research in the second semester of the junior year and the first semester of their senior year; the project may also be undertaken during the senior year. Students who do well on their research project will graduate with department honors. Students planning to pursue this option should take History 202 in the spring of their junior year. Honors students may plan special programs, including more in-depth study of two cultural areas rather than three.

Department Major Requirements

A history major consists of 33 hours; normally 11 courses.

History 11, 12 Survey of European History I and II.

Maximum of nine additional hours in courses below the 100 level, including any Advanced Placement credit.

History 201 or 202 (students planning to pursue independent research are strongly urged to take History 202).

Minimum of 12 additional hours of courses at the 200 or 300 level.

At least one course from each of the groups listed below:

group a courses

Hist 7	The Machine in America (3)
Hist 8	History of Medicine in America (3)
Hist 9	Survey of American History I (3)
Hist 10	Survey of American History II (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 124	Women in America (3)
Hist 129	Black Political Thought in America (3)
Hist 130	African American History to 1865 (3)
Hist 131	African American History since 1865 (3)
Hist 135	United States, 1789-1840 (3)
Hist 136	United States, 1840-1877 (3)
Hist 137	United States, 1877-1920 (3)
Hist 138	United States, 1920 to 1945 (3)
Hist 139	United States, 1945 to Present
Hist 180	Religion and the American Experience (3)
Hist 231	American Diplomatic History (3)
Hist 307	American Industrial Technology (3)
Hist 310	American Military History (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)

Hist 338	Psychohistory (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)
Hist 360	American Constitutional and Legal History (3)

group b courses

Hist 15	English History (3)
Hist 16	English History (3)
Hist 21	Greek History (3)
Hist 22	Roman History (3)
Hist 149	The Barbarian West (3)
Hist 150	Medieval Civilization (3)
Hist 151	Popular Religion in the Christian West (3)
Hist 152	Women in Antiquity (3)
Hist 154	The Holocaust: History and Meaning (3)
Hist 157	The Renaissance and Reformation (3)
Hist 158	Early Modern Europe (3)
Hist 159	Modern Europe (3)
Hist 160	Modern Europe (3)
Hist 161	Roman Law (3)
Hist 214	Age of Caesar and Christ (3)
Hist 215	Decline and Fall of the Roman Empire (3)
Hist 220	Golden Age of Greek Democracy
Hist 241	Conservatism in the Modern Age (3)
Hist 243	English History, 1471-1660 (3)
Hist 244	English History 1660-1789 (3)
Hist 245	Victorian Britain (3)
Hist 246	Great Britain in the 20th Century (3)
Hist 261	Russia to 1855 (3)
Hist 262	Russia since 1855 (3)
Hist 263	Early Modern Germany, 1500-1850 (3)
Hist 264	Modern Germany, 1850 to Present (3)
Hist 337	History of Medical Thought (3)
Hist 355	European Cultural History I (3)
Hist 356	European Cultural History II (3)
Hist 357	English Constitutional and Legal History to 1783 (3)

group c courses

Hist 5	African Civilizations (3)
Hist 31	History of Japanese Industrialization since 1800 (3)
Hist 49	History of Latin America (3)
Hist 50	History of Latin America (3)
Hist 75	Chinese Civilization (3)
Hist 166	Intro to Japanese Civilization (3)
Hist 171	History of Southern Africa (3)
Hist 172	History of West Africa (3)
Hist 176	Topics in East Asian History (3)
Hist 265	Mexico and the Caribbean (3)
Hist 266	Argentina, Brazil and Chile (3)
Hist 368	Seminar in Latin American History (3)

Hist 300, 301, 371, 372, 391, 392, or provisional courses will be placed in one of the above groups in accordance with their contents and emphases.

History majors are encouraged to choose electives from among economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and social relations. Students intending to do graduate work should acquire a reading knowledge of at least one foreign language, choosing languages appropriate to their area of concentration.

Minor Programs

A student may establish a minor program in history that covers either a geographical, topical, or chronological interest (American, European, technological and medical, or twentieth century history, to mention a few possibilities). Each student's minor program is prepared in consultation

with the advisor of minors in the history department.
Advanced placement credit may not be used for the minor program.
 The minor totals at least fifteen hours and conforms to the following pattern:

- * six hours in courses numbered below 100
- * maximum of six hours in 100 level courses
- * minimum of three hours in courses numbered above 200

Undergraduate Courses in History

Petitions are required for Freshmen to take 100-level or higher courses, and for Sophomores to take 200-level or higher courses.

5. (AAS 5) African Civilizations (3)

Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade, colonialism, resistance to European rule, independence movements, and neocolonialism. Keim, Scott

7. The Machine in America (3)

American technology since colonial times. Changes in techniques and organization of processing, manufacturing, transportation and construction; consideration of social, cultural, and economic impact. Smith, Cooper

8. History of Medicine in America (3)

Institutional development of the American medical profession. Ellis

9. Survey of American History I (3) fall

Social, economic, cultural and political institutions through Reconstruction, emphasizing their effects on public policy and culture. Staff

10. Survey of American History II (3) spring

American culture, politics, and society from the late nineteenth century to the present, emphasizing the impact of industrialization. Smith, Cooper, Simon

11. Survey of European History I (3) fall

Development of European history from Rome to the 17th century. End of the ancient world, origins and growth of medieval civilization, the Renaissance and Reformation. Baylor

12. Survey of European History II (3) spring

Europe from the seventeenth century to the late twentieth. Development of the state system and cultural life during the *ancien régime*; the impact of the French and industrial revolutions; nationalism and liberalism in the nineteenth century; the two world wars and the end of European supremacy. Baylor

15. English History (3) fall

The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England. Duffy

16. English History (3) spring

English political and social institutions from 1688 to the present. The evolution of parliamentary government, the rise of modern parties, the industrial revolution, and recent social philosophies. Duffy

21. (Clss 21) Greek History (3) fall

The development of civilization from paleolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic, and literary development of the ancient world; the origin of political institutions. Phillips

22. (Clss 22) Roman History (3) spring

Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips

31. History of Japanese Industrialization since 1800 (3)

The late Tokugawa economic development, rise of an entrepreneurial class, importation of western technology, and the rise of social, political, and economic institutions which support industrial growth. Cooper

49. History of Latin America (3) fall

Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and Iberian backgrounds. Saeger

50. History of Latin America (3) spring

Continuation of Hist 49. The development of the Latin American nations in the nineteenth and twentieth centuries. Saeger

75. (MFL 75) Chinese Civilization (3)

Traditional Chinese customs, beliefs, values and institutions and their influence outside China. Thought, literature and the arts in the imperial age. Pankenier

111. Engineering in the Modern World (3)

Roles played by engineers and engineering in the modern world, focusing on major achievements and failures, prominent engineers, and evolution of the profession. Smith

119. Colonial America (3) fall

Founding and growth of colonies in North America through circa 1750. Attention will be paid to motives behind European expansion as well as to developments in the colonies.

120. Revolutionary America (3) spring

American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution.

124. Women in America (3)

Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. Shade, Cooper

129. (AAS 129) Black Political Thought in America (3)

Examination of black political thought, leadership and movements for social justice in the United States from 1880 to 1968. The lives, ideas and programs of major black leaders: Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X, and Martin Luther King, Jr. Scott

130. (AAS 130) African American History to 1865 (3) fall

Blacks in North America and the West Indies from the first importation of Africans until the end of the Civil War. Topics include: West Africans origins, slave trade, variant slave systems, black culture, free blacks, manumission movements, proslavery ideology, and blacks during the Civil War.

131. (AAS 131) African American History Since 1865 (3) spring

The failure of Reconstruction, sharecropping, Jim Crowism, segregation, lynching, urban migration, the Harlem Renaissance, the New Deal, the Civil Rights movement, and affirmative action. Scott

132. (Eco, Govt, IR) An Introduction to Canada (3)

An interdisciplinary, team-taught course focusing on history, politics, economics, and international relations. Topics covered will include Canada's historical development, recent politics and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States.

135. United States, 1789-1840 (3)

The American political system from the Constitution through Jacksonianism. Special emphasis upon the first and second party systems and the democratization of American political culture. Shade

136. United States, 1840-1877 (3)

Civil War and Reconstruction, emphasizing the causes of the Civil War, its impact upon American society and politics, and problems of postwar reconstruction. Shade

137. United States, 1877-1920 (3)

Political, economic and social responses to industrial America. The rise of the Populist and Progressive movements, coming of World War I, and postwar developments. John Ellis

138. United States, 1920-1945 (3)

World War I and its legacy; prosperity, crash and the coming of the New Deal. The rise of fascism and World War II. Dowling

139. United States, 1945 to Present (3)

Problems of post-World War II America emphasizing the Cold War and "McCarthyism", Korea, Vietnam and the rise of neo-Conservatism. Analysis of political, social and economic events from Truman to Reagan. Dowling

145. (STS 145) Introduction To the History of Science (3)

The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century. Goldman

149. The Barbarian West (3) fall

Merger of Greco-Roman, Germanic and Christian institutions and culture in Western Europe to mid-eleventh century. Evolution of the church, feudalism and manorialism, and the foundations of the Carolingian and Holy Roman empires. Tipton

150. Medieval Civilization (3) spring

Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. Tipton

151. Popular Religion in the Christian West (3)

Cult Christianity as understood and practiced by medieval people, including residual paganism, superstitions, cult of saints and relics, heresy, witchcraft and other religious elements of mass appeal. Tipton

152. (Clss 152/WS 152) Women in Antiquity (3)

Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. Phillips

154. (Rel 154) The Holocaust: History and Meaning (3) spring

The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust.

157. (Rel 157) The Renaissance and Reformation (3) fall

Transition from medieval to early modern society: decline of medieval civilization; political, social and cultural changes of the Renaissance; the varieties of Protestantism; the wars of religion. Baylor

158. Early Modern Europe (3) spring

Transformation of European civilization from the 30 Years War to the outbreak of the French Revolution. Origins and development of the European state system; absolutism; commercial expansion and competition for empire; science; the Enlightenment and its impact on European culture and politics. Baylor

159. Modern Europe (3) fall

Revolutions and reactions in Western Europe from 1789 to 1870. The rise and spread of liberalism and the origins of socialism. Duffy

160. Modern Europe (3) spring

Contemporary Europe; the origins and consequences of two world wars; the rise of revolutionary governments in Italy, Germany and Russia. Duffy

161. (Clss 161) Roman Law (3)

Examination of Roman legal systems from the *Twelve Tables* to the *Digest* of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips

166. (Rel 166) Introduction to Japanese Civilization (3)

The history and culture of Japan from its origins to the present. Special consideration will be given to the rise and fall of the warrior class, developments in art and religion, the dynamics of family life, and Japan's "economic miracle." Kraft

171. History of Southern Africa (3)

Africa south of the Zambesi, especially after the arrival of the Europeans in the Cape, with special attention to conflicts between Africans, Boers and British, exploitation of minerals, apartheid, American policy, and socialism in Angola and Mozambique. Scott

176. Topics in East Asian History (3)

Topics in major societies of East Asia.

180. (Rel 180) Religion and the American Experience (3) fall

The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship.

For Advanced Undergraduates And Graduate Students

201. Historical Perspectives (3) spring

Methodologies and interpretations of Western historians from ancient times to the present. Baylor

202. Introduction to Historical Research (3) spring

An introduction to historical interpretation, research design, and methodology. Students will study an historical topic or topics through secondary and primary sources. Honors candidates will apply this knowledge to a design of their thesis project. Required of all students planning to pursue an honors thesis. Permission of Department chairman required.

203. Public History in America (3) fall

An examination of the public role of history in American life. The origins of museums, historical societies, archives and historic preservation with emphasis on the various uses of history by different segments of society. Bastoni

214. (Clss 214) Age of Caesar and Christ (3) spring

Roman History of the first century A.D. Political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. Phillips

215. (Clss 215) Decline and Fall of the Roman Empire (3)

Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips

220. (Clss. 220) Golden Age of Greek Democracy

Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. Phillips

241. Conservatism in the Modern Age (3)

Conservative thought from the eighteenth century to

present, including Burke, romantic conservatism, classical liberalism, and the response to industrialism and technology. Tipton

243. English History, 1471-1660 (3) fall

England under the Tudor monarchy and the problems facing its successors culminating in the civil wars and Interregnum. Political, economic, intellectual and religious developments of the period.

244. English History 1660-1789 (3) spring

Constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy, especially the political, social, economic and intellectual sectors.

245. Victorian Britain (3) fall

Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain. Duffy

246. Great Britain in the 20th Century (3) spring

Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem on 20th century Britain. Duffy

261. Russia to 1855 (3) fall

Emergence of Russian autocracy; impact of the Mongol invasions; Westernization and transformation of society and culture; economic development toward emancipation of the serfs. Kohls

262. Russia Since 1855 (3) spring

Russia in the context of European history: emancipation of the serfs and impact upon political, social, economic development; reasons for the growth of revolutionary pressure; collapse of autocracy; the revolutions of 1917; the Soviet era and the collapse of the Soviet Union. Kohls

263. Early Modern Germany, 1500-1850 (3) fall

The emphasis will be on one or more of the following topics: the Reformation, the 'Thirty Years' War and its impact, absolutism, the rise of Prussia, the failure of German liberalism.

264. Modern Germany, 1850 to Present (3) fall

Focus on one or more of the following topics: nationalism and unification, the Second Empire, World War I, the Weimar republic, the Nazi movement, the Third Reich, and post-war Germany. Baylor

265. Mexico and Central America (3) spring

Emphasis on Mexico and Guatemala from the era of the Aztec through the wars of independence to the twentieth century revolutions. Saeger

266. Argentina, Brazil and Chile (3)

Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, twentieth-century extremist movements, and the problems of developing nations. Saeger

271. United States and Africa (3)

Reciprocal relationships between North America and the African continent from the slave trade in the seventeenth century to the twentieth century Afrocentric movement; impact of Americans on the shaping of modern Africa, Pan-African relations; influence of African Americans on US policies toward Africa. Scott

301. Seminar in the History of Technology (3)

Readings and research in the history of technology and engineering education. Students will pursue topics of individual interest around a general theme. Simon, Smith, Cooper

307. History of American Industrial Technology (3)

Origin and evolution of american technology and industry from the nineteenth century to the present. Investigates

dynamics of major industries in national and international contexts. Smith

310. American Military History (3) spring

The American military tradition from colonial times to the present. America's wars and the development and operation of military institutions within the political, economic, ideological, and technological milieu of American society. Saeger

315. American Environmental History (3)

Relationship between Americans and their natural environment from the colonial period to the present: impact of European settlement, attitudes toward wilderness, role of technological development, rise of preservation and conservation movements, establishment of national parks, recent environmental protection legislation. Cutcliffe

325. (SSP 325) American Social History, 1607-1877 (3) fall

Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade

326. (SSP 326) American Social History Since 1877 (3) spring

Changing role of women, minorities, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Prerequisite: Any one of the following: Hist 10, 137, 138, or 139, or consent of department chairman. Simon

327. American Intellectual History (3) fall

Development of political, social and religious ideas in America from the colonial period to the Civil War. Dowling

328. American Intellectual History (3) spring

Economic, political and religious thought in industrial America, 1860 to present. Dowling

333. American Urban History to 1880 (3) fall

Planning and design of colonial and frontier cities. Impact of transportation innovations and industrialization, emergence of a national system of cities. Internal problems of early industrial cities: housing, transportation, public health, crime, social mobility. Simon

334. American Urban History, 1880 to Present (3) spring

Physical expansion of the industrial city and its relationship to current urban problems. Suburbanization, development of the central business district, reforms in housing and public health, rise of ghettos, emergence of the city planning profession and the idea of 'new town,' impact of the New Deal and 'urban renewal.' Simon

337. History of Medical Thought (3)

From prehistory to present: shamanism and healing, Greco-Roman medicine, Paracelsus and Harvey, and the germ theory of disease. Ellis

338. Psychohistory (3) spring

Uses of psychology in history and biography; exploration of problems of methodology, verification of evidence, conceptual frameworks and theories of personality; potentialities and limitations of psychological investigation as an historical technique. Dowling

339. Topics in American Public Health (3)

Reading and research on topics in the history of the American public health movement. Prerequisite: Hist 8. Ellis

340. Topics in American Medicine (3)

Reading and research on topics in the history of American medicine. Prerequisite: Hist 8. Ellis

355. (Rel 355) European Cultural History I (3) fall

Major developments in European culture from the late Middle Ages through the 17th century. Late scholasticism,

humanism and the Renaissance, varieties of Protestantism, origins of modern science. Baylor

356. European Cultural History II (3) spring
Transformation of European culture from the 18th century to the present. The Enlightenment, cultural impact of the French and industrial revolutions, romanticism and ideologies of the 19th century, contemporary European thought. Baylor

357. English Constitutional and Legal History to 1783 (3) spring
Origins and development of government, administration and law from Anglo-Saxon times to 1783, emphasizing common-law institutions, practices and procedures. Duffy

360. American Constitutional and Legal History (3) fall
Adoption of the federal constitution and its modification and expansion: Anglo-American legal tradition and its transformation. Shade

361. (Arch 361) Evolution of Highrise Building Construction (3)
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. Peters

363. (Arch 363) Evolution of Long-Span Bridge Building (3)
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. Peters

365. (Arch 365) Evolution of the Modern Building Process (3)
The criteria of trade—time and money—entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. Peters

368. Seminar in Latin American History (3)
Readings and individual investigation of selected topics. Saeger

371. Special Topics in History (1-3)
Intensive study in an area of history not adequately covered in currently listed offerings. The course may be administered as a reading program or otherwise as may seem best to meet the needs of students of unusual ability and adequate preparation. Prerequisite: consent of the department chairman.

372. Special Topics in History (1-3)
Continuation of History 371. Prerequisite: consent of the department chairperson.

391. Honors Thesis in History (3)
Opportunity for undergraduate majors in History or American Studies to pursue an extended project for senior honors.

392. Honors Thesis in History (3)
Continuation of History 391.

For Graduate Students

Lehigh University has been granting advance degrees in history for more than half a century. Its graduates have become university and college professors, secondary school teachers and administrators, museum directors, and public servants. The graduate program focuses primarily on the areas in which the department is particularly strong in faculty and resources, notably Colonial America and the history of Technology, Science, and Medicine. The department works closely with the Lawrence Henry Gipson Institute for Eighteenth Century Studies which sponsors yearly symposia and provides research support for both faculty and students. The history of Technology program is

closely tied to Lehigh's Science, Technology, and Society program.

Lehigh's libraries are especially rich in materials for graduate research in history, particularly in the fields listed above. It has an extensive collection of scholarly periodicals and monographs. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for the Graduate School, the following special requirements apply to graduate study in history.

Master of Arts

There are two masters programs. Under Plan I, a candidate may earn the degree by successfully completing twenty-seven hours of approved course work and submitting a thesis of the length and quality that would make it suitable for publication as a scholarly article. The paper may build on work presented in a graduate research seminar in the program. A student seeking to present a lengthier master's thesis may do so with twenty-four hours of approved course work. Candidates continuing toward a doctorate should select Plan I. Candidates declaring Plan II take thirty hours of approved course work and pass examinations in two fields chosen from American, British, European and Latin American history, and history of science and technology. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take at least one research seminar.

Doctor of Philosophy

Candidates for the doctor of philosophy in history must maintain a 3.25 history average and a 3.0 over-all average on all graduate work taken at Lehigh or elsewhere. Students entering with a master's degree take a qualifying examination before beginning their second semester at Lehigh. During the second semester, doctoral students select two major and two minor fields in which to take comprehensive written and oral examinations. The candidate will also choose a dissertation field and a dissertation advisor who will chair the special committee which will oversee the student's graduate program. The other members of the special committee will be those faculty who are examiners in the selected fields and one professor from outside the department relevant to the candidate's major field. The candidate will then, in consultation with the members of the committee, prepare for the examination in those fields. The special committee may compel additional work beyond the minimum requirements given above. No professor may direct more than one field, but the direction of a field may involve two professors. An original dissertation is required and may be written only in a major field and must be successfully defended to the examining committee.

Major Fields. Major fields are Technology, Modern Britain, Colonial America, Nineteenth Century United States, Twentieth Century United States. (The Nineteenth and Twentieth century fields may be divided topically rather than chronologically; for example, a student may be examined in labor/social history, 1800-present and in political history, 1800-present.)

Minor Fields. Any of the major fields listed above may also be minor fields. Other minor fields may be Ancient History; Medieval and Early Modern Europe; Modern Europe; Latin America; Science; Medicine; Science, Technology and Society studies.

Language requirements. The qualifying examination in one language must be passed before beginning course work beyond the master's degree in order that the language may be used in doctoral course work. The candidate's special committee, appointed by the chairman of the department, will designate any additional languages for the student, if needed. Languages normally chosen are French, Spanish, Italian, German or Russian. Graduate-level competence in statistical methods and computer application are acceptable as replacement for a foreign language. All graduate majors

take Hist 401 and either 404 or 405. All Ph.D. candidates must take 18 hours of directed readings and two research seminars. More detailed regulations are given in the *Handbook for Graduate Work in History*, available in the history department office.

401. Methods in Historical Research (3) fall

Techniques of research in history: training in the critical handling of documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Required of all graduate students in history. Shade

404. Historiography: Europe (3)

The approach, methods and interpretations of the leading historians of Europe.

405. Historiography: America (3)

The approach, methods and interpretations of the leading historians of America.

415. Introduction to the History of Technology in Western Civilization (3)

Analysis and historiography of the history of technology. Smith

440. Readings in Colonial American History (3)

Study in small groups under the guidance of a faculty member of the literature of the seventeenth and eighteenth centuries. May be repeated for credit with the permission of the department chairman.

441. Readings in Nineteenth Century American History (3)

Study in small groups under the guidance of a faculty member of the literature of the nineteenth century. May be repeated for credit with the permission of the department chairman.

442. Readings in Twentieth Century American History (3)

Study in small groups under the guidance of a faculty member of the literature of the twentieth century. May be repeated for credit with permission of the department chairman.

443. Readings in English History (3)

Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the department chairman.

444. Readings in Latin American History (3)

Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the department chairman.

445. Readings in the History of Science (3)

Study in small groups under the guidance of a faculty member on the history of science. May be repeated for credit with permission of the department chairman.

446. Readings in the History of Technology (3)

Study in small groups under the guidance of a faculty member of the history of technology. May be repeated for credit with the permission of the department chairman.

447. Readings in European History (3)

Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem or aspect of European history. May be repeated for credit with permission of the department chairman.

452. Research in American History (3)

An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chairman.

453. Research in English History (3)

An intensive research seminar on a phase of English history.

May be repeated for credit with permission of the department chairman.

454. Research in Latin American History (3)

An intensive research seminar on a phase of Latin American history. May be repeated for credit with permission of the department chairman.

455. Research in History of Science and Technology (3)

An intensive research seminar on a phase or aspect of the history of science and technology. May be repeated for credit with permission of the department chairman.

457. Research in European History (3)

An intensive research seminar on phase of European history. May be repeated for credit with permission of the department chairman.

471. Special Topics in History (1-3)

Individual study under direction of a faculty member of a topic in history. May be repeated for credit.

472. Special Topics in History (1-3)

Individual study under direction of a faculty member of a topic in history. May be repeated for credit.

Industrial Engineering

Professors. Marlin U. Thomas, Ph.D. (Michigan), *chairperson*; Keith M. Gardiner, Ph.D. (Manchester, England); Mikell P. Groover, Ph.D. (Lehigh); Nicholas G. Odrey, Ph.D. (Penn State); John C. Wiginton, Ph.D. (Carnegie-Mellon); Emory W. Zimmers, Jr., Ph.D. (Lehigh). **Associate professors.** John W. Adams, Ph.D. (North Carolina); Louis J. Plebani, Ph.D. (Lehigh); G. Sathyanarayanan, Ph.D. (Michigan Tech); Robert H. Storer, Ph.D. (Georgia Tech); Gregory L. Tonkay, Ph.D. (Penn State); George R. Wilson, Ph.D. (Penn State); Szu-Yung David Wu, Ph.D. (Penn State). **Assistant professor.** Laura Burke (Ph.D.) (University of California-Berkeley).

Industrial engineering (IE) is concerned with the analysis, design and implementation of integrated systems of people, materials, information, and equipment to accomplish useful work. The discipline of industrial engineering is applicable in nearly all industries, whether the industry is involved with the manufacture of a product or the delivery of a service. Some of the job functions performed by industrial engineers are: planning of manufacturing processes, selection of equipment, analysis of work methods, work measurement, cost estimation, scheduling of production, inventory control, quality control, investment analysis, production line supervision, project management, and management of production and engineering organizations.

Career Opportunities

Industrial engineering graduates are sought by nearly all industrial corporations as well as government agencies and institutions. In addition to the manufacturing industries, which are the traditional companies that hire IEs, other employers of our graduates have included management consulting firms, banks, hospitals, airlines, railroads, the postal service and private deliverers. The typical career path of an industrial engineering graduate is to start in an entry level engineering position or line supervision, and progress to a management position in the firm or institution. Significant numbers of industrial engineers ultimately become chief executive officers of their respective organizations.

The Curriculum

The curriculum is designed to provide graduates with the skills and knowledge that employers expect of young industrial engineers beginning their professional careers. It

includes the basic mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design that are specific to the industrial engineering discipline. These principles and methods include probability and statistics, engineering economics, cost accounting, operations research, manufacturing processes, work methods and measurement, production and inventory control, and information systems.

The IE curriculum also requires students to choose electives from the basic engineering sciences such as materials science, statics, strength of materials, mechanics of fluids, electrical circuits, thermodynamics, and control systems. In addition, recognizing the importance of the liberal arts, nearly one-fifth of the graduation requirement is devoted to English, economics, and other humanities courses.

Specialized industrial engineering electives in the senior year include: computer integrated manufacturing, industrial robotics, facilities planning, production engineering, data and information processing, microprocessor systems, data communication systems, and advanced operations research techniques.

Physical Facilities

The Industrial Engineering Department is located in the Mohler Laboratory Building at the northwest corner of the Asa Packer Campus. Mohler Lab contains the classrooms, faculty offices, and laboratories of the department.

The **manufacturing technology laboratory** contains equipment for instruction and research in manufacturing processes, assembly, automation, control systems, material handling and storage, and metrology.

The **computer-integrated manufacturing (CIM) laboratory** presents the student with an opportunity to use a wide range of computer systems. Classroom instruction and hands-on exercises typically include computer-aided design, systems analysis, wireframe modelling, simulation, software development, N/C part programming, database management, local area networking, data collection, process design and process control.

The **information systems laboratory** serves the student by presenting opportunities in interactive programming, data processing, and data base systems.

The **microprocessor laboratory** serves the student by providing an opportunity to gain understanding and design skill in the application of microprocessors to industrial engineering situations.

An interdisciplinary **robotics and automation laboratory** provides students with the opportunity to gain first-hand experience with the various types of robots and automated equipment and to gain skill in planning their use.

The **work systems laboratory** affords the opportunity to students to analyze and plan human activities at both individual work stations and in the monitoring of multiple machine stations. This is accomplished in part through the use of microprocessor-driven simulators.

Considerable use is made of the university Computing Center facilities in all levels of course work.

Areas Of Emphasis In Industrial Engineering

The Industrial Engineering Department at Lehigh emphasizes four areas in its 300 level courses: manufacturing systems (MS), operations research (OR), information systems (IS), and operations management (OM). The IE curriculum includes fifteen credit hours of advanced (300 level) industrial engineering courses and six credit hours of free electives, so that students can emphasize one of these areas if they choose. In the list below, the areas with which each course is identified are indicated by the two-letter code. Students can elect courses from one or more areas to meet their individual objectives.

- IE 305 Simulation (3) - MS, OR
- IE 307 Advanced Systems Analysis and Design (3) - IS
- IE 310 Database Analysis and Design (3) - IS
- IE 316 Advanced Operations Research Techniques (3) - OR

- IE 319 Material Handling & Facilities Planning (3) - MS, OM
- IE 324 Industrial Robotics (3) - MS
- IE 332 Product Quality (3) - MS, OM
- IE 334 Organization Planning and Control (3) - OM
- IE 339 Queuing Theory (3) - OR
- IE 340 Production Engineering (3) - MS, OM
- IE 341 Data Communication Sys Analysis and Design (3) - IS
- IE 342 Computer Integrated Manufacturing (3) - MS, IS, OM
- IE 343 Microprocessor Systems in IE (3) - IS
- IE 344 Metal Machining Analysis (3) - MS

Special Programs

The following special programs are available to industrial engineering majors.

Nontechnical minor. Students may choose to pursue a nontechnical minor in an area of the humanities and social sciences. The **Minors Program** section of the university catalog should be consulted for details. Examples of areas selected as minors include classics, economics, history, international relations, philosophy, and psychology. Most nontechnical minors require 15 credit hours of coursework in the department, which can usually be satisfied within the 21 credit hours of humanities and social sciences and free electives.

Master of Business Administration. Undergraduates in industrial engineering may choose electives that satisfy prerequisite requirements in the master's degree program in business administration, thus permitting them to complete the MBA in one additional year beyond the four-year BSIE program. The MBA prerequisite courses, some of which are included in the regular IE curriculum, are listed below:

- | | |
|----------|--|
| Acct 151 | Introduction to Financial Accounting (3) (Substituted for Acct 108 in the regular IE curriculum) |
| Acct 152 | Introduction to Managerial Accounting (3) |
| Acct 324 | Cost Accounting (3) |
| Eco 119 | Intermediate Microeconomic Analysis (3) |
| Eco 229 | Money and Banking (3) |
| IE 121 | Applied Engineering Statistics (3) (All IE undergraduates take this course) |
| IE 221 | Operations Research - Probabilistic Models (3) (All IE undergraduates take this course) |
| Law 201 | Legal Environment of Business (3) |

Students who do not take Acct 152 and Acct 324 as undergraduates will be required to take Acct 413 as part of their MBA coursework. Students who do not take both Eco 119 and Eco 229 as undergraduates will be required to take Eco 409 as part of their MBA coursework.

Most of the courses in the prerequisite list can be rostered as regular IE courses, free electives, or humanities and social sciences. Some overloading or summer school will be required to complete the entire list within the four-year period. A grade of B or better must be achieved in each course for it to be credited toward the MBA Program. Upon completion of the four-year BSIE curriculum, and assuming the student is admitted to the Graduate School, the additional 39 credit hours of MBA coursework can be completed within two regular semesters and two summer sessions.

Major Requirements

freshman year see page 34

sophomore year, first semester (16 credit hours)

- IE 111 Engineering Probability and Statistics (3)
- IE 112 Computer Graphics (1)

Math 23	Analytic Geometry & Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
Mat 33	Engineering Materials and Processes (3)

sophomore year, second semester (16 credit hours)

IE 121	Applied Engineering Statistics (3)
IE 122	Software Tools (1)
IE 124	Engineering Economy and Decision Analysis (3)
ME 104	Thermodynamics I (3)
Acct 108	Principles of Microeconomics or Macroeconomics (3)
Eco 11 or 12	Fundamentals of Accounting (3)

junior year, first semester (16 credit hours)

IE 115	Fundamentals of Modern Manufacturing (3)
IE 116	Manufacturing Laboratory (1)
IE 221	Operations Research - Probabilistic Models (3)
Math 205	Linear Methods (3)
Mech 2	Elementary Engineering Mechanics (3)
HSS	Humanities/Social Sciences elective (3)

junior year, second semester (17 credit hours)

IE 131	Work Systems and Facilities Planning (3)
IE 132	Work Systems and Facilities Planning Laboratory (1)
IE 222	Operations Research - Deterministic Models (3)
IE 224	Information Systems Analysis and Design (3)
ECE 81	Principles of Electrical Engineering (4)
IE	elective (3)

summer

IE 100	Industrial Employment (0)
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senior year, first semester (18 credit hours)

IE 251	Production and Inventory Control (3)
IE	elective (3)
IE	elective (3)
ESE	engineering science elective (3)
HSS	Humanities/Social Sciences elective (3)
FE	free elective (3)*

senior year, second semester (18 credit hours)

IE 154	Senior Project (3)
IE	elective (3)
IE	elective (3)
HSS	Humanities/Social Sciences elective (3)
HSS	Humanities/Social Sciences elective (3)
FE	elective (3)*

Notes:

- (1) The engineering science elective is chosen
- (2) Any course can be used as a free elective
- (3) IE elective courses are chosen from the current offering of 300-level IE courses

Undergraduate Courses**100. Industrial Employment (0)**

Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: Sophomore standing.

111. Engineering Probability and Statistics (3) fall
Random variables, probability models and functions, and expected values. Statistical inference, estimation, hypothesis testing, and goodness of fit. Prerequisite: Math 22.

112. Computer Graphics (1) fall

Introduction to interactive graphics and construction of multi-view representations in two- and three-dimensional space. Applications in industrial engineering. Prerequisite: Sophomore standing in industrial engineering, Engr. 1.

115. Fundamentals of Modern Manufacturing (3) fall

Study of modern production methods. Machining and other metal working processes, electrical and electronics manufacturing, and nontraditional processing. Introduction to automation, numerical control, and industrial robots. Prerequisite: Mat 63.

116. Manufacturing Laboratory (1) fall

Laboratory exercises and experiments in manufacturing processes and systems. Prerequisite: IE 115, either previously or concurrently.

121. Applied Engineering Statistics (3) spring

The application of statistical techniques to solve industrial problems. Topics include regression and correlation, analysis of variance, quality control, and reliability. Prerequisite: IE 111 or Math 231.

122. Software Tools (1) spring

Introduction to application software tools, including word processing, spreadsheets, and statistical packages. Problems for solution will be drawn from other courses in the sophomore program. Prerequisites: Engr. 1; IE 121, 124 concurrently.

124. Engineering Economy and Decision Analysis (3) spring

Economic analysis of engineering projects; interest rate factors, methods of evaluation, depreciation, replacement, break-even analysis, after-tax analysis. Decision-making under certainty and risk. Prerequisite: IE 111 or Math 231, either previously or concurrently.

131. Work Systems and Facilities Planning (3) spring

Techniques of methods analysis, work measurement, and facilities design. Man-machine systems, assembly systems, operations analysis, time study, predetermined time systems, work sampling, incentive systems, plant layout, and materials handling. Prerequisite: IE 121, either previously or concurrently.

132. Work Systems and Facilities Planning Laboratory (1) spring

Laboratory exercises and projects in methods analysis, operations analysis, plant layout, and related topics. Prerequisite: IE 131, either previously or concurrently.

154. Senior Project (3) fall and spring

The use of industrial engineering techniques to solve a major problem in either a manufacturing or service environment. Problems are sufficiently broad to require the design of a system. Consideration of human factors in the system design. Laboratory. Prerequisite: Senior standing in industrial engineering.

168. Production Analysis (3) fall and spring

A course for the engineering student not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement and scheduling, and operating systems analysis. Prerequisites: Math 22 or 42; Eco 1.

For Advanced Undergraduates and Graduate Students

221. Operations Research - Probabilistic Models (3) fall
Probabilistic models in operations research. Topics include queueing theory, probabilistic inventory models, Markov

analysis, and simulation, including use of a simulation language. Prerequisite: IE 111 or Math 231.

222. Operations Research - Deterministic Models (3) spring
Deterministic models in operations research. Topics include linear programming, integer programming, networks, dynamic programming, and classical optimization. Prerequisite: Math 205.

224. Information Systems Analysis and Design (3) spring
An Introduction to the technological as well as methodological aspects of computer information systems. Content of the course stresses basic knowledge in database and data communication systems. Topics include: database design and evaluation, query languages, software implementation, data communication networks and data transmissions.

251. Production and Inventory Control (3) fall
Techniques used in the planning and control of production and inventory systems. Topics include forecasting, inventory models, operations planning, and scheduling. Prerequisite: IE 221, either previously or concurrently, and IE 121, IE 222.

305. Simulation (3)
Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high level simulation language. Design of simulation experiments. Prerequisites: IE 221 and IE 222.

307. Advanced Systems Analysis and Design (3) spring
Study of advanced techniques and their application in the analysis and design of information systems. Emphasis is placed on tools and techniques used for structured analysis and design, and on prototyping of systems. Prerequisite: IE 224 or equivalent.

309. Introduction to Information Systems (3) fall
Study of information systems analysis and design with emphasis on management issues. Interfaces between information systems and databases and data communications are examined. Effects of information systems on organizational relationships are considered. Example information system will be designed and implemented. Prerequisite: IE 224 or equivalent.

310. Database Analysis and Design (3) spring
Conceptual analysis of data is considered through data structures and models. Logical design of databases is studied in the context of the relational model of data. Prerequisite: IE 224 or equivalent.

316. Advanced Operations Research Techniques (3)
A survey of advanced topics in operations research. Topics include advanced linear programming, dynamic programming, integer programming, decision analysis, game theory and nonlinear programming algorithms. Prerequisites: IE 221 and IE 222.

319. Material Handling and Facilities Planning (3)
Material handling systems, storage systems and automatic identification. Facilities planning including layout planning and facility location. Prerequisite: IE 131 or consent of department chair.

321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required. May be repeated for academic credit.

324. Industrial Robotics (3)
Introduction to robotics technology and applications. Topics include robot anatomy, controls, sensors, programming, work cell design, part handling, welding, and assembly. Laboratory exercises. Prerequisites: Mech 2, Math 205.

332. Product Quality (3)
Introduction to engineering methods for the monitoring

control and improvement of product quality. Topics include statistical models of quality measurements, statistical process control, acceptance sampling, and quality management principles. Some laboratory exercises. Prerequisite: IE 121.

334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of industrial engineering. Analysis and design of resources planning and control, including introduction of change in man-machine systems; manpower management and wage administration. Prerequisite: IE 131 or 168.

339. Queuing Theory (3)
Models for analyzing waiting lines and congestion systems. Methods and techniques for formulating Markov and non-Markov queues, networks, and approximation techniques. Prerequisite: course in probability theory.

340. Production Engineering (3) fall
Develop plans of manufacturing for discrete parts. Product design analysis and engineering materials utilization. Economic analysis of process design alternatives. Introduction to mechanization, automation, and flexible manufacturing systems. Term project. Laboratory. Prerequisite: IE 115.

341. Data Communication Systems Analysis and Design (3)
An introduction to the hardware as well as performance evaluation of data communication networks. Emphasis on data transmission, encoding, data link control, communication networking techniques, and queuing/simulation analysis of network performance. Prerequisite: IE 224 and IE 221 or equivalent.

342. Computer Integrated Manufacturing (3) spring
Analysis and design of manufacturing systems using digital computers. Principal topics: computer-aided techniques, group technology, applications of minicomputers to manufacturing systems. Introduction to adaptive control, numerical control, and optimization strategies for discrete parts manufacturing. Term project. Prerequisite: IE 224, IE 115 or equivalent.

343. Microprocessor Systems in IE (3) fall
Fundamentals of microprocessors and microcomputers for industrial engineering applications. Topics include basic digital concepts, microprocessor programming interfacing, data acquisition and system development for timing, counting, decision making and control. Laboratory. Prerequisite: IE 224 and IE 115 or equivalent.

344. Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 115 and/or Mech 12.

345. Manufacturing Information Systems (3)
This course examines the foundations for information systems required to support the manufacturing function throughout the product life cycle. Students will be exposed to the problems of design, implementation, and management by way of assigned readings, class discussion of cases, and a research project.

Graduate Programs

Programs leading to the master of science and doctor of philosophy degrees are offered by the department in the following fields: manufacturing systems, information systems, and operations research.

These programs, briefly described, are as follows:

M.S. in Industrial Engineering

The minimum program for the master of science degree consists of twenty-four credit hours of approved course work and completion of a satisfactory thesis.

A master of science program is selected to meet the interests and needs of the student, and courses in other

departments for which the student has the prerequisites may be integrated into the major field. Subject to proper approval, nine credit hours of 400-level courses from outside the department may be included among the courses required in the major field. As part of a purposeful major program, collateral courses may be taken in other branches of engineering, mathematics, economics, psychology, and information and computer science.

M.S. in Management Science

The department and the College of Business and Economics administer an interdisciplinary program leading to a master of science degree in management science. Students are admitted and may enroll in either department for administrative purposes. The minimum program consists of thirty credit hours of approved course work.

M. Eng. in Industrial Engineering

This program of study is for those students whose interests are toward design rather than research. This program will provide opportunity to gain breadth of field by required course work in all areas of study within the department. In addition, a design project is carried out under the supervision of the faculty that further emphasizes breadth of field.

Ph.D. in Industrial Engineering

This program is organized to meet the individual goals and interests of industrial engineering students who plan to engage in teaching, consulting, or research activities in industrial, governmental, or educational environments.

Each doctoral student is required to demonstrate competency in several broad fields of industrial engineering related to a personal area of interest and prepare, through formal course work and independent study, for examination in the particular area of specialization by members of the faculty. A dissertation related to the field of specialization is required.

Further information about the doctor of philosophy program is contained in the Graduate School section and in a brochure available from the department.

Areas of Graduate Study

The areas of graduate study and research that are emphasized in the department are as follows:

Operations Research. The operations research program is intended to prepare students to recognize, formulate and solve problems using combinations of analytic methods and techniques. These methods include linear programming, combinatorial optimization, queueing theory and statistics.

There are many settings in which problems solvable by operations research methods are encountered, but those which arise in the context of the manufacturing or service industries are of particular interest at Lehigh. Students can expect to encounter and study challenging and important problems at either the Masters or Ph.D. levels.

Information Systems. Graduate study in information systems includes course work and research in advanced systems analysis and design, artificial intelligence, communication systems, advanced manufacturing information systems, as well as long-range and strategic planning for information systems. Additional related courses are offered in other departments and colleges. In particular, the graduate business program offers courses on the management and implementation of technology-based systems. The information systems area is supported by a laboratory containing a variety of interconnected configurations of equipment providing extensive support for both MS-DOS and UNIX operating system-based languages and tools.

Manufacturing Systems. Graduate study in manufacturing systems and production engineering involves course work and research in various topics related to manufacturing. These topics include computer integrated manufacturing (CIM), automation and numerical control, robotics, process control, metal machining, material handling, work systems, and production control. Additional related courses are

offered in other departments in the College of Engineering and Applied Science. The manufacturing systems area is supported by several departmental laboratories, including the Manufacturing Technology Laboratory, Computer Integrated Manufacturing Laboratory, Robotics and Automation Laboratory, and the Work Systems Laboratory.

A related graduate program is the interdisciplinary program in Manufacturing Systems Engineering (MSE), leading to the Master of Science degree. Details about this MSE Program are described elsewhere in this catalog.

The department offers courses during the late afternoon and early evening for the convenience of students who are employed in local industry and are taking graduate work on a part time basis.

405. Special Topics in Industrial Engineering (3)

An intensive study of some field of industrial engineering.

408. (Acct 433) Management of Information Systems (3)

Philosophies and methods for systematic planning, development, and implementation of management information systems. Concepts of information resource management, and strategic and long-range planning of information systems and services. Prerequisite: IE 224 or Acct 311 or equivalent.

409. Data Dependent Systems (3)

Theory and applications of an approach to process modeling, analysis, prediction, and control based on an ordered sequence of observed data. Single or multiple time series are used to obtain scalar or vector difference/differential equations describing a variety of physical and economic systems.

410. Design of Experiments (3)

Experimental procedures for sorting out important causal variables, finding optimum conditions, continuously improving processes, and trouble shooting. Applications to laboratory, pilot plant and factory. Prerequisite: Some statistical background and experimentation in prospect.

411. Networks and Graphs (3)

This course examines the theory and applications of networks and graphs. Content of the course stresses on the modeling, analysis and computational issues of network and graph algorithms. Topics include: complexity theory, trees and arborescences, path algorithms, network flows, matching and assignment, primal-dual algorithms, Eulerian and Hamiltonian walks and various applications of network models.

415. Manufacturing Management (3)

Analysis of the factors entering into the development of manufacturing management philosophy; decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

416. Dynamic Programming (3)

The principle of optimality and recursive solution structure; multidimensional problems; reduction of dimensionality and approximation; stochastic control; non-serial systems; relationship to calculus of variation; applications. Prerequisite: IE 316 or equivalent.

417. (Mgt 445) Advanced Mathematical Programming (3)

Theoretical and algorithmic structure of optimization methods; search strategies for unconstrained optimization; conditions for constrained optima; algorithmic strategies for smooth and non-smooth constrained problems. Applications in stochastic multiobjective, equilibrium, and large scale mathematical programs. Prerequisite: IE 316 or equivalent.

419. Sequencing and Scheduling (3)

Systematic analysis of models for production planning and scheduling. Topics include facility location and production allocation; resource planning techniques; hierarchical

planning; static and dynamic scheduling of activities to production (or project) resources. Prerequisites: IE 251 and IE 316 or equivalent.

421. Nontraditional Manufacturing Processes

Analysis of the processes, sensors, machine tools, and control systems in water jet cutting, electrochemical machining, electric discharge machining, laser and ion beam machining, and ultra high precision machining processes. Prerequisite: Consent of department chair.

424. Robotic Systems and Applications (3)

Detailed analysis for robotic systems in manufacturing and service industries. Topics include task planning and decomposition, motion trajectory analysis, conveyor tracking, error detection and recovery, end effector design, and systems integration. Prerequisite: IE 324 or consent of chairperson.

428. Advanced Work Systems (3)

A critical evaluation of methods improvement and work measurement techniques. Emphasis on design of work systems, productivity improvement, and reporting systems to control work. Work sampling, construction of standard data, mathematical models of work systems.

429. Artificial Intelligence Techniques in Combinatorial Optimization (3)

Study of Artificial Intelligence techniques applied to practical combinatorial optimization problems such as routing, scheduling, partitioning, network design, and VLSI layout/placement. Content of the course includes: NP-completeness, exact and approximation algorithms, heuristic search methods, and probabilistic search methods such as simulated annealing, genetic algorithms and Tabu search. Prerequisite: IE 222, or IE 316 or equivalent.

430. (Mgt 430) Management Science Project (3) spring

An analysis of a management problem and design of its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

431. Operations Research Seminar (3)

Extensive study of selected topics in techniques and models of operations research.

433. Manufacturing Engineering Seminar (3)

Extensive study of selected topics in the research and development of manufacturing engineering techniques.

437. Advanced Database Analysis and Design (3)

Intensive treatment of design and application of modern database technology, including information modeling and logical design of databases. Particular emphasis on applications to the manufacturing environment. Prerequisite: IE 310 or equivalent.

438. Advanced Data Communication Systems Analysis and Design (3)

Study of technological development, operational algorithms and performance analysis in data networks. Emphasis on the recent development in communication technologies, modeling and simulation of large scale networks, routing models and algorithms, and flow control issues. Prerequisite: IE 341 and IE 316, or equivalents.

439. Applications of Stochastic Processes (3)

Introduction to stochastic processes, application in queueing theory and inventory theory. Prerequisites: a course in probability theory and IE 317.

443. Automation and Production Systems (3)

Concepts and principles of automated production lines; analysis of transfer lines; partial automation; mechanized assembly system; flexible manufacturing systems; industrial robots; line balancing; product and process design considerations.

444. Design of Cutting Tools (3)

A study of design parameters including tool materials, tool geometry and cutting conditions for material removal operations. Emphasis will be placed on the influence of tool selection variables, on economy of operation and conformance to product requirements.

448. Industrial Control Systems for Manufacturing (3)

Techniques used to control manufacturing systems: numerical control, digital control, programmable logic controllers, and sensors. Prerequisite: IE 343 or consent of department chair.

449. Advanced Computer-Aided Manufacturing (3)

Numerical control in manufacturing; CAD/CAM systems; computer monitoring and control of manufacturing operations; adaptive control of manufacturing operations. Manufacturing resource planning, computer-aided process planning, and shop floor control. Prerequisite: IE 342 or consent of the department chair.

450. Manufacturing Problems (3)

Discussion and solution of manufacturing problems involving several subfunctions, with emphasis on problem identification and definition; selection of techniques of analysis; procedures for evaluation of proposed solutions.

460. Engineering Project (1-6)

An intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

461. Readings (1-3)

Intensive study of some area of industrial engineering which is not covered in general courses.

490. Thesis (1-6)

499. Dissertation (1-15)

Interdisciplinary Technology Courses

See listings under Science, Technology and Society.

International Careers

Alvin Cohen, Ph.D. (Florida), professor of economics and *director*, International Careers major.

This major in the College of Arts and Science is designed to meet the needs of the student who has decided upon an international business, or political focus for his education. It uses elements of the traditional liberal arts and business school curricula. Among those traditional liberal arts elements are courses in economics, government, history, international relations, and language. With respect to business school offerings, there are courses in accounting, finance, and statistics. The major also represents an excellent foundation for graduate study in business, law, and the social sciences.

Each student completes the courses in the common core, takes twelve credit hours from offerings in economics, government, history, international relations, and social relations as related to an area of geographical concentration, and eighteen credit hours in a functional option. Although not a requirement, students should study the language related to their area of specialization.

Major Requirements

Common Core

(18 credit hours)

Eco 11	Micro Principles (3)
Eco 12	Macro Principles (3)
Govt 3	Comparative Politics (3) or IR 10 (3)
Math 41	or its equivalent (3)
Eco 145	or its equivalent (3)
Acct 51 or 108	(3)

Geographical Concentrations

(12 credit hours from any one of the four areas)

Latin America, Europe, East Asia, the Middle East

Functional Options

Pick one of the two listed below:

International Business (12 credit hours)

Eco 229	Money and Banking (3)
Eco 303	Economic Development (3)
Eco 339	International Trade (3)
Eco 340	International Finance (3)

Public Administration (12 credit hours)

Eco 353	Public Finance (3)
IR 353	International Institutions (3)
Govt 322	Politics of Developing Nations (3) or
Eco 303	Economic Development (3)
Govt 360	Public Administration (3)

International Relations

Associate Professor and Chairperson: Bruce E. Moon, Ph.D. (Ohio State).

Professors. M. Rajan Menon, Ph.D. (Illinois), *Monroe J. Rathbone Professor*; Oles M. Smolansky, Ph.D. (Columbia), *University Professor*; Raymond F. Wylie, Ph.D. (London-England).

Associate professor. Henri J. Barkey, Ph.D. (Pennsylvania).

Assistant professors. Chaim D. Kaufmann, Ph.D. (Columbia); Katja Weber, M.A. (UCLA).

Emeritus Professors. Carey B. Joynt, Ph.D. (Clark); Zdenek J. Slouka, Ph.D. (Columbia).

The Field of International Relations: The reality of an interdependent world is brought home to us every day. Fast-flying, highly accurate nuclear weapons have breached the state's ability to protect its citizens as never before. National economies are so sensitive to the trade and monetary policies and instability of other countries that governments are forced to recognize the limitations of purely national economic policies in a highly interdependent world. Resource depletion, pollution, refugee relief, the indebtedness of developing countries, and nuclear proliferation are truly global problems beyond the ability of any one state, no matter how powerful, to address alone. In sum, International Relations is not a remote abstraction that educated men and women can afford to ignore.

The Department of International Relations seeks to provide students with a systematic understanding of world politics. The questions that preoccupy scholars of International Relations are too numerous to list here, but students who major in International Relations can expect to acquire a detailed knowledge of topics such as: contending theories of world politics; theories of foreign policy decision-making; the foreign policies of the major powers; international security and arms control; regional conflicts; global problems such as terrorism, refugee relief, and pollution; international political economy; and the role of international organizations such as the United Nations, the

International Monetary Fund, and the World Bank. As should be apparent from this list, International Relations is a multi-disciplinary field and draws upon concepts and theories from Political Science, History, Economics, Anthropology, Sociology, Philosophy, Religion Studies, and Psychology. Our majors are encouraged to take courses in these disciplines.

The Curriculum: To meet our educational goals, the Department of International Relations devised a new curriculum in 1992 to take effect from the 1993-94 academic year. It consists of four segments: 1) A lower-level core comprising four courses and a one-hour laboratory; 2) An upper-level core of four courses; 3) A research seminar; 4) A functional or geographic concentration made up of three courses in International Relations and other related disciplines. A synopsis is provided below. The curriculum will be explained in full when students visit the Department to declare a major.

Students may also minor in International Relations by taking the lower-level core **plus** one other course offered by the Department.

Beyond Curriculum: In close cooperation with the Center for International Studies, the department assists students interested in "study abroad" programs. In addition, Lehigh has an array of summer programs—which involve course work and/or internships—in such countries as England, Belgium, France, and Guatemala.

Every semester a variety of speakers with expertise on various aspects of world affairs visit Lehigh. Together with the Center for International Studies, the department arranges the annual Cohen International Lecture Series, which has featured speakers such as Robert McNamara, Peter Lord Carrington, Valéry Giscard d'Estaing, Vaclav Havel, and Hans Dietrich Genscher.

The student-run International Relations Club organizes the Model United Nations. Each year, it selects students for Model UN conferences held at Princeton, Harvard, and other universities, and for student conferences at West Point and the US Naval Academy. The department also offers an internship program for students interested in working at Lehigh's Office of Community Relations and International Students/Scholars Office.

Upon Graduating: We are often asked about the employment prospects of students who major in International Relations. While our primary intent is not to equip our students with a trade suited for the "job market", we take very seriously their questions regarding career planning. While a degree in International Relations does not lead to a specific career in the way that, for example, accounting or engineering does, a major in International Relations, by emphasizing clarity in speech and writing, analytical skills, and a detailed knowledge of world politics prepares students for careers in government, journalism, law, international business, and teaching and research. Our majors currently work in all of these fields. Some have gone directly into careers upon graduating; others have enrolled in graduate school prior to employment.

Major in International Relations

Required lower level core (4 courses plus lab)

IR 10	Introduction to World Politics (3)
IR 101	Theories of International Relations (3)
IR 102	Rise and Decline of Empires (3)
IR 125	International Political Economy (3)
IR 110	Laboratory in International Relations (1)

Required upper level core (one course from each of four areas)

Foreign Policy (IR 211)
Political Economy (IR 221, 222, or 223)
International Security (IR 232)
International Institutions (IR 241 or 242)

Research seminar (one course at the 300 level)**Area concentration (3 courses):**

Choose from a single geographic area such as East Asia, Russia, or Latin America or a single functional area such as political economy or decision-making. See department for list of possible concentrations and precise list of courses approved for each.

Departmental Honors

To graduate with honors, a major in international relations must

- (a) attain an average of at least 3.5 in the courses constituting the major program;
- (b) demonstrate a reading competence in a foreign language; and
- (c) complete a 6-credit honors thesis in the senior year.

Minor in International Relations

The minor program is designed for undergraduates of any college who wish to acquire a knowledge of international relations in addition to their major. **Requirements:** Completion of lower level core required for the major (see above); and one other IR course.

Undergraduate Courses**IR 10. Introduction to World Politics (3)**

Introduction to the major principles, concepts, and theories of international relations, along with a historical background focusing on the 19th and 20th centuries. Topics to be covered include the nature of power, balance of power theories, national interest, decision-making in foreign policy, theories of war and expansion, patterns of cooperation, and international political economy. Staff

IR 33. War and World Politics (3)

The role of war in the modern world; the impact of social, economic, and technological change on the function and conduct of war; World Wars I and II; Vietnam; the nuclear revolution; possible future developments. Kaufmann, Barkey

IR 61. East Asian International Relations (3)

Introduction to East Asian international relations with emphasis on post-1945 period; historical background; Cold War conflicts; China's rise to power; Japan's growing role; Korea and the NICs; Southeast Asia; U.S. and Russian policies; current and future issues. Wylie

IR 71. United States Foreign Policy (3)

Major themes and trends in U.S. foreign policy, with attention to both the historical evolution of contemporary policy and key current problems. Emphasis is upon critical examination of the interests and values that underlie the goals of policy and the theories that shape perceptions of how they can be met. Sources of U.S. policy, including decision-making structures, policy processes, and the role of the public and media. Moon, Kaufmann

IR 81. Middle East in World Affairs to 1945 (3)

Political, economic, and social forces behind the rise of modern states in the Middle East; area's role in international politics from Napoleon's invasion of Egypt to the end of World War II. Smolansky

IR 82. Middle East in World Affairs Since 1945 (3)

Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East as the world's major oil producer. Smolansky

IR 101. Theories of International Relations (3)

Examination of various theoretical approaches to international relations and their application to historical and contemporary cases. Levels of analysis; balance of power; hegemonic stability theory; cause of war; role of nuclear weapons. Prerequisite: IR 10. Weber, Kaufmann

IR 102. Rise and Decline of Empires (3)

An overview of the expansion, over-extension, and collapse of empires. Focus on alternative theories of empires as well as historical cases. Prerequisite: IR 10. Menon

IR 110. Laboratory in International Relations (1)

Basic elements of research and writing for international relations majors. Topic selection, search techniques, basic library resources, thesis formulation, canons of evidence, rules of citation. Must be taken concurrently with either IR 101 or IR 102. Staff

IR 119. Issues in International Relations (3)

Readings on selected themes in world politics, with theme to change each semester. Prerequisite: IR 101 or IR 102. Staff

IR 125. International Political Economy (3)

Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy and its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1 or 11 or 12; IR 10. Moon, Barkey

IR 132. (Eco, Hist, IR) An Introduction to Canada (3)

An interdisciplinary, team-taught course focusing on history, politics, economics, and international relations. Topics covered will include Canada's historical development, recent politics and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States. Staff

IR 162. China in World Affairs (3)

China in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Third World; current and future issues. Wylie

IR 163. Japan in World Affairs (3)

Japan in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with major powers; policies toward Third World; current and future issues. Wylie

IR 164. (RS 164) Japan's Response to the West (3)

A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft

IR 167. Diplomacy of Russia to 1917 (3)

Expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist governments, treated partially as background of Soviet policy; interaction between Russian domestic and foreign affairs. Smolansky

IR 168. Diplomacy of the USSR, 1917-1991 (3)

Topical and chronological survey of Soviet foreign relations; Soviet efforts to survive in a 'hostile capitalist environment'; consolidation of gains made during World War II; origins of Cold War; frictions within the Communist Bloc (Eastern Europe, China); nuclear arms race; striving for detente; activity in the Third World; Gorbachev and collapse. Smolansky

IR 169. The Soviet Collapse and World Politics (3)

The transformations in Soviet foreign policy that resulted from the advent of Gorbachev in 1985, the consequent changes in East-West relations, and the impact in Eastern Europe, Africa, South Asia (India, Pakistan, Afghanistan), and Latin America. Prerequisites: IR 10 and 102. Menon

IR 177. International Relations in Latin America (3)

Survey of major international and domestic crises facing Central and South America. Examines factors affecting Latin American system of states such as international debt, involvement of foreign powers, and social and political instabilities. Barkey

IR 211. Theories of Foreign Policy (3)

Sources of foreign policy, including economic and domestic structure; the roles of bureaucracies and individual leaders; the impact of beliefs and images; learning from history; psychological explanations. Prerequisite: IR 101 and IR 102. Kaufmann

IR 221. Economic Relations of Advanced Industrial Societies (3)

Foreign economic policies of advanced industrial nations. Bilateral and multilateral economic relations; international economic regimes and institutions; interdependence and cooperation; managing conflict. Prerequisites: IR 125. Moon

IR 222. Political Economy of North-South Relations (3)

Political economy of relations between developed and less developed countries. Explanations for choices of development policy, especially issues of trade, foreign aid, and foreign direct investment. Consequences of North-South transactions. Controversies over system structure and international institutions. Prerequisites: IR 125. Moon, Menon

IR 223. The Political Economy of Newly Industrializing Countries (3)

Issues of development, debt and adjustment in newly industrializing countries. Analysis of the differences between the development strategies adopted in Latin America and East Asia. Explanations for patterns of success and failure. Origins of underdevelopment; the politics of failed development strategies; the challenge of the increasingly competitive world economy and relations with the U.S. and other developed nations. Prerequisite: IR 125. Barkey

IR 232. The Role of Force in International Relations (3)

Theories of war and international insecurity; arms races; influence of domestic politics and bureaucracies; misperception. Tools of war prevention; deterrence; alliances; collective security; arms control. Nationalism; the nuclear and information revolutions; the changing usefulness of force. Prerequisites: IR 101 and IR 102. Kaufmann, Weber

IR 241. International Law (3)

Function of law in international relations. Foundation and structure of international law. Sources of international legal rights and obligations. International law-making and settlement of disputes. Prerequisites: IR 101 and IR 102. Staff

IR 242. International Institutions (3)

Role of international institutions in world politics. Origins, interplay and functions of intergovernmental and nongovernmental organizations. Possible role of supranational organizations in replacing or modifying the present state-centered system. Special emphasis given to NATO, the United Nations and the European Community. Prerequisites: IR 101 and IR 102. Weber

IR 246. (Jour 246) International Communication (3)

Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule

IR 251. The International Relations of Western Europe (3)

Research-oriented seminar on Western Europe's international relations, with heavy emphasis on relations with the United States and recent events: analysis of major political and economic developments since 1945; study of significant changes of the post-Cold War period to ascertain whether relations between the Western Allies can be

expected to be conflictual or cooperative. Prerequisites: IR 101 and IR 102. Weber

IR 306. Seminar in International Relations Theory (3)

Analysis of new trends in international relations theory, selected from: the obsolescence of major war; the resurgence of nationalism; the role of change and continuity, integration and disintegration, conflict and cooperation in international relations. Prerequisite: IR 101 and IR 102. Weber

IR 312. Seminar in Psychology and Foreign Policy (3)

Analysis of selected advanced topics in the processes, politics, or psychology of foreign policy decision making. Prerequisite: IR 211, or consent of instructor. Kaufmann

IR 326. Seminar in International Political Economy (3)

Analysis of selected issues in contemporary international economic relations. A substantial research paper on a topic of the student's own choice is required. Topic varies each year. Prerequisites: IR 221, IR 222, or IR 223. Moon, Barkey

IR 333. Seminar in International Security (3)

Analysis of selected advanced topics in war prevention, strategy, or U.S. defense policy. Prerequisite: IR 232 or consent of instructor. Kaufmann

IR 339. Seminar in Revolutions and International Relations (3)

The impact of revolutions on the international system of states. The adjustments of existing states to emerging revolutionary regimes: war, military intervention, and diplomatic conflict. The influence of revolutionary regimes from the French Revolution to the contemporary Soviet Union, Iran and Cuba. Prerequisite: IR 101 and 102. Barkey

IR 344. Seminar in International Law (3)

Case studies in the dynamics of international regulatory processes. Political, socio-economic, and cultural foundations of the international legal system. Prerequisite: IR 241. Staff

IR 364. Seminar in the International Relations of East Asia/Pacific Rim (3)

Research-oriented seminar on contemporary international relations of East Asia/Pacific Rim. Special emphasis on China, Japan and regional organizations. Substantial research paper on topic of students' own choice is required. Prerequisite: IR 61, 163 or 164. Wylie

IR 367. Seminar in the International Relations of Russia and Eastern Europe (3)

Analysis of the international causes and consequences of the Soviet Union's collapse, the foreign relations of Russia and the other states of the former USSR. Prerequisites: IR 168 or IR 169. Menon, Smolansky

IR 377. Seminar in Canada-United States Relations (3)

Research-oriented seminar on Canada's relations with the United States, with emphasis on post-1945 period. Substantial research paper on topic of students' own choice required. Wylie

IR 384. Seminar in International Relations of the Middle East (3)

Importance of the Middle East in contemporary world politics; strategic location and natural resources as factors affecting interests of the great powers. Interplay of international, regional and internal forces. Prerequisites IR 81 or IR 82. Smolansky

IR 371. Reading in International Relations (3)

Directed course of reading intended for students with special competence or interest in fields of international relations and fully covered by regular course offerings. May be repeated for credit. Departmental permission required.

IR 372. Reading in International Relations (3)

Continuation of IR 371. Departmental permission required.

IR 391. Special Topics (3)

Intensive study of some aspects of international politics not covered in another course. May be repeated for credit. Departmental permission required.

IR 392. Special Topics (3)

Continuation of IR 391. Departmental permission required.

IR 395. Internship in International Relations (3)

Internship in public or private agency. May be repeated for credit. Departmental permission required.

Japanese

See Listings under Modern Foreign Languages.

Journalism and Communication

Professor. Sharon M. Friedman, M.A. (Penn State), *chairperson and director of science writing program.*

Associate professors. Carole M. Gorney, M.S.J., A.P.R. (Northwestern); Jack Lule, Ph.D. (Georgia); Walter W. Trimble, M.A. (Ohio State).

Assistant professors. Frankie Hutton, Ph.D. (Rutgers); Dina Wills, Ph.D. (Oregon).

Adjunct professors: Kenneth Friedman, Ph.D. (Penn State); Glenn Kranzley, B.A. (Penn State); Robert Rosenwein, Ph.D. (Michigan); Nancy S. Ross, M.A.T. (Cincinnati); William White, M.A. (Ohio State).

The department of journalism and communication offers major and minor programs in print journalism and science writing as well as a minor program in public relations. It also jointly sponsors an interdisciplinary communication minor with the Communication Studies Program.

The profession of journalism deals with the truthful communication and explanation of facts. It is the purpose of the program in journalism to bring its majors to a point at which they can gather significant information, organize it quickly and communicate it clearly, accurately and objectively. It also aims to bring students to an understanding of the legitimate role of the mass media in society.

The first of these objectives is attained by extensive, professionally oriented practice in the reporting, writing and editing of the news. Emphasis is placed on precision and clarity of expression and sophistication of style.

The second objective is attained by study of the rights and responsibilities of the mass media under the U.S. Constitution and by a senior seminar course in which problems facing the media and the relationship between the media and society are examined.

In the basic journalism program, students take courses in news and feature writing, editing, law and ethics, reporting, and a seminar in mass media. In addition, many students pursue a concentration in at least one of the following areas: American studies, economics, government, history, international relations, languages, literature, philosophy, religion studies, various scientific disciplines, social relations and urban studies. Some journalism students elect to pursue a double major. Others choose a minor or a concentration in one of these fields.

A second major program available to students is the science writing major, which encompasses training in science, environmental and technical writing. Those selecting this major will learn to write about pure and applied scientific research, technology, engineering, the environment and medicine and health for a variety of audiences ranging from the general public to scientists and engineers in industry and government. A minor in science writing is available for those who wish to major in science or

engineering and become skilled in science communication techniques.

All science, environmental and technical writing students may enroll in the science writing field research program, which offers a unique opportunity for practical experience in scientific research and science writing. They also may gain experience by serving on the staff of *Science Scope*, a student-written publication devoted to research at Lehigh.

A public relations minor is available to students interested in a career in such areas as nonprofit, governmental and corporate public relations. The courses offered cover theory, skills and practical application of public relations.

An interdisciplinary minor in communication is offered jointly with the Communication Studies Program for students interested in developing oral communication skills and a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, one-to-one and small group communication.

Although most journalism graduates choose some phase of written communication as a career—newspapers, wire services, magazines, broadcasting, public relations, advertising—others have used their background in journalism as a basis for the study and practice of law, graduate study in a variety of disciplines, government service, teaching and business management.

Those concentrating in science writing can expect to pursue careers in science journalism; in public information or public relations for scientific societies, government agencies, universities or hospitals; in technical writing for industry and government agencies; and in other areas, such as management, administration and teaching, in which science communication skills are highly desirable. The program also prepares students for graduate study in science writing, journalism and other disciplines.

Students who complete the public relations minor will be prepared for both entry-level positions and for management responsibilities that are likely to occur later in the students' careers. Studies in writing, communication and media give minors a grasp of the basics essential for the first job in public relations. An emphasis on planning, programming and management techniques provides the background needed to respond to advancement opportunities in the field.

The interdisciplinary minor in communication will be useful to students interested in organizational and written communication, law, business, philosophy, government, marketing, teaching, telecommunication or other careers where successful communication is important.

Basic Journalism Major

required preliminary courses

Jour 1	Brown & White (1)
Jour 11	News Writing (4)

required major courses

Jour 2-3	Brown & White (2)*
Jour 12	Feature Writing (3)
Govt 177	Urban Politics (3)
Jour 113	Editing (3)
Jour 122	Media Ethics and Law (3)
Jour 214	Reporting of Public Affairs (4)
Jour 315	Advanced Reporting (3)
Jour 320	Journalism Proseminar (3)
Jour 361	Internship (3)

plus two of the following:

Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 127	Public Relations Principles (3)
Comm 130	Public Speaking (3)
Jour 135	Human Communication (3)
Jour 141	Photojournalism (3)
Comm 143	Persuasion and Influence (3)
Comm 144	Effective Interviewing (3)
Jour 215	Advanced Editing (3)
Jour 246	International Communication (3)
Jour 240	Writing for Broadcasting (3)

Jour 327	Mass Communication & Society (3)
Comm 331	Business and Professional Speaking (3)

(Not all elective courses are taught every year.)

Thirty-eight credits are required.

*Note: A minimum of three semesters is required on *The Brown and White*. The course involves work on the student newspaper. One of the three required semesters must be taken during the student's junior year, and one must be taken during the senior year.

Dual major and recommended electives. Journalism majors are encouraged to declare dual majors in journalism and another field, such as one of those discussed under concentrations above. In-depth knowledge of a specialty area is considered an asset to a journalism career. Those not desiring to declare a dual major should consider either declaring a minor in one of these fields or concentrating their elective courses in one or two of these areas. Dual majors, minors and concentration areas should be chosen in consultation with the major adviser.

Journalism/Science Writing Major

required preliminary courses

Jour 1	Brown & White (1)
Jour 11	News Writing (4) or
Jour 123	Basic Science and Technical Writing (3) or
Jour 314	Communicating Technical Information (3)

required major courses

Jour 2-3	Brown & White (2)**
Jour 113	Editing (3)
Jour 122	Media Ethics and Law (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 128	Writing for Public Relations (3)
Jour 214	Reporting of Public Affairs (4)
Jour 323	Scientific and Environmental Controversies (3)
Jour 361	Internship (3)
Govt 177	Urban Politics (3)

Thirty-four journalism credits are required.

**Note: A minimum of three semesters is required on *The Brown and White*. The course involves work on the student newspaper. One of the three required semesters must be taken during the student's junior year, and one must be taken during the senior year.

Required science courses. A minimum of twenty-four credits in the physical, biological, environmental or social sciences or engineering is required. These hours can be concentrated in any one area or distributed among all five areas, although an area concentration is recommended. Dual majors in journalism/science writing and a science are encouraged. Science courses should be chosen in consultation with the major adviser.

Science writing field research program. Available to science, environmental and technical writing students at the junior or senior level, this program provides practical experience in scientific research and science writing for students who work on and write about research projects directed by university scientists and engineers.

Another segment of the program allows students to attend major scientific meetings as fully accredited science reporters. Students observe professional science writers in action and write their own stories about the scientific sessions and press conferences held at the meetings.

Journalism Minor

Students who wish to declare a minor program in journalism must be majors in another discipline and take the following:

Jour 1-2	Brown & White (2)
Jour 11	News Writing (4)
Jour 12	Feature Writing (3)
Jour 113	Editing (3)

One other Journalism course above the 100 level (3)

Fifteen credits are required.

Science Writing Minor

Students desiring to minor in science writing must be majors in another discipline, preferably a science or engineering.

The following courses are required:

Jour 1-2	Brown & White (2) or
Jour 361	Internship (2)
Jour 11	News Writing (4) or
Jour 123	Basic Science and Technical Writing (3) or
Jour 314	Communicating Technical Information (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 312	Advanced Science Writing (3) or
Jour 323	Scientific and Environmental Controversies (3)

One other Journalism or Communication course (3)

Seventeen or eighteen credits are required.

Public Relations Minor

Students minoring in public relations must be majors in another discipline and take the following courses:

Jour 11	News Writing (4) or
Jour 123	Basic Science and Technical Writing (3)
Jour 127	Public Relations Principles (3)
Jour 128	Writing for Public Relations (3)
Jour 229	Public Relations Case Studies (3)
Jour 306	Applied Public Relations (3) or
Jour 361	Internship (3)

plus one of the following:

Jour 129	Specialized Writing in Public Relations (3)
Jour 215	Advanced Editing (3)
Jour 240	Writing for Broadcasting (3)
Comm 331	Business and Professional Speaking (3)

Eighteen or nineteen credits are required.

Communication Minor

See description under Minor Programs in the College, page 26.

Computer Writing Laboratories

Students taking journalism courses will receive extensive experience with mass media computer applications. All writing and editing labs are conducted in one of the department's two computer rooms. One is a newspaper production facility with a mixed network of 20 DOS and Macintosh computers, in which the DOS computers are used for text entry and the Macintosh computers are used for pagination of publications. All are connected through a local area network to laser and postscript printers and are used extensively for desktop publishing. The other facility is a local area network with 20 DOS computers, laser printers and an overhead projection system for classes, labs and demonstrations.

Journalism Courses

NOTE: Some journalism and communication courses *require* departmental permission before students can register for the class. Check the course schedule each semester.

Media Internships

All majors in journalism and journalism/science writing are required to take an internship to acquire professional experience with area newspapers or magazines, or in an institutional, public relations or advertising setting. Science writing minors may take an internship instead of working on *The Brown and White*.

1. Brown and White (1) every semester

Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper. Newspaper staff members are *selected* based on their interests and skills. Students who preregister for this course are told at the beginning of the semester whether they have been selected for the staff. First- and second-semester freshmen are given priority. Prerequisite: Freshman or sophomore standing; juniors only with consent of department chairperson.

2-10. Brown and White (1-2) every semester

Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper. Newspaper staff members are *selected* based on their interests and skills. Students who preregister for this course are told at the beginning of the semester whether they have been selected for the staff. Prerequisite: Jour 11 or Jour 123 or consent of the department chairperson.

11. News Writing (4) every semester

Preparation and practice in gathering and writing news; definition and components of news; structure and style of the news story; introduction to interviewing and editing.

12. Feature Writing (3) every semester

Defining and developing feature stories: human interest, historical, color, personality and news issues; specialized interviewing and writing techniques. Prerequisite: Jour 11 or Jour 123. Hutton

113. Editing (3) every semester

Study of and practice in newspaper desk work; headline writing, makeup, and typography; selecting, editing and rewriting news and feature copy; use of reference works and newspaper libraries. Prerequisite: Jour 11 or Jour 123. Trimble

122. Media Ethics and Law (3) spring

First Amendment theory and history; ethical and legal issues involving libel, privacy, obscenity, newsgathering, access, and fair trials; national and international concerns over censorship, prior restraint and manipulation and control of information. Prerequisite: Jour 11, Jour 123 or Law 11. Lule

123. Basic Science and Technical Writing (3) every semester

Writing about science and technology subjects for audiences ranging from lay persons to scientists and engineers. Includes instruction in news and feature writing plus interviewing for lay audiences, with emphasis on organization and clear writing techniques. As course progresses, material becomes more technical in nature, concentrating on how to write effective technical reports, progress reports, letters and memos. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman

124. (STS 124) Politics of Science (3) spring

Organization of the U.S. scientific community; interaction with federal government, mass media and society; history of science-government connection; role of science advisory system; technological controversies. S. Friedman

125. Environment, the Public and the Mass Media (3) fall

Exploration of environmental problems and public perceptions about them. Roles played in environmental

controversies by government, environmental groups, industry and mass media. Risk communication about environmental hazards. S. & K. Friedman

127. Public Relations Principles (3) fall

Emphasis on management function of public relations, including research, planning, programming, communications and evaluation. Study of non-profit and persuasion theory, public opinion, crisis management and ethics. Student teams apply theory to practical organizational problems. Gorney

128. Writing for Public Relations (3) spring

Study of the preparation and writing of publicity for the print media and various publications (newsletters, pamphlets, annual reports), especially for non-profit and environmental groups. Prerequisite: Jour 11 or 123 or 311 or consent of department chairperson. S. Friedman, Gorney

129. Specialized Writing in Public Relations (3) fall

Preparation and writing of promotional and publicity materials, including public service announcements, for radio and television; preparation of audio-visual materials and presentations; planning and conducting news conferences; media interview techniques in negative situations; writing informational and persuasive speeches for others. Students will produce finished public service announcements and will be videotaped giving actual media interviews. Prerequisite: Jour. 11 or 123 or consent of department chairperson. Gorney

135. (Spsy 135) Human Communication (3)

Processes and functions of human communication in relationships and groups. Rosenwein

141. Photojournalism (3) summer

Ethics and history of photojournalism; practice in techniques of distinguished photojournalists, camera use and darkroom. Students must provide own 35mm. camera. Trimble, Gorney

214. Reporting of Public Affairs (4) spring

Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisites: Jour 11 or 123 and Govt 177. Trimble

215. Advanced Editing (3)

Study of the techniques of newspaper, magazine and pamphlet design: typography and other visual elements, preparation of copy and artwork, use of microcomputer-based desktop publishing. Prerequisite: Jour 113 or permission of the department chairperson. Trimble

220. Reporting on Business and Economics (3)

The principles behind the economy, the markets and companies and how to report on them; the role of business reporting in the media; the use of computer technology in business reporting. Prerequisite: Jour 11 or Jour 123 and Eco 1.

229. Public Relations Case Studies (3) fall

Analysis of public relations programs in business, industry, government, and non-profit organizations. Emphasis on specific problems and methods used. Prerequisite: Jour 127 or consent of department chairperson. Gorney

231. Science Writing Practicum (1-3)

On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of Science Writing Field Research Program. May be repeated for a maximum of eight credits. Prerequisites: Jour 11 or Jour 123 or Jour 311, junior standing, and consent of the department chairperson. S. Friedman

233. Public Relations Practicum (1-3)

Practical experience in public relations competitive programs sponsored by professional and academic societies.

May be repeated for a maximum of eight credits.
Prerequisites: Jour 127, junior standing and consent of department chairperson. Gorney

240. Writing for Broadcasting (3) spring
Basic writing style for radio and television, and packaging of newscasts. Write, edit and present on-air newscasts and public affairs programs for the campus radio station. Assigned reading for class discussion related to the history, technology and regulation of broadcasting. Gorney

246. (1R 246) International Communication (3)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule

306. Applied Public Relations Study (3) spring
Application of crisis planning, management and communication to problems faced by organizations. Teams develop crisis plans and strategies for real clients and engage in mock news conferences to practice effective media interviews. Prerequisites: Jour 127 and Jour 128 or consent of department chairperson. Gorney

311. Science and Technical Writing (3) every semester
Study of and practice in writing about science and technology for general print and specialized science publications. Includes news and feature articles, report writing and analysis of factors that influence science communication to the public. Emphasis on writing and organizational skills and translation of scientific materials into lay language. Should be taken by upperclass and graduate students instead of Jour 123. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman

312. Advanced Science Writing (3)
Further practice, on individual basis, in science writing techniques. Prerequisite: Jour 123 or 311. S. Friedman

313. Special Topics in Science Communication (1-3)
Research or writing involving a topic, medium or issue in science, environmental or technical communication not covered in other courses. Prerequisite: Nine hours in science or environmental writing or consent of the department chairperson. S. Friedman

314. Communicating Technical Information (3)
For upperclass students planning on graduate school and graduate students: instructions in writing about technical subjects from an academic perspective. Laboratory reports, journal articles, thesis and dissertations, proposals and oral technical presentations will be highlighted. Prerequisite: Junior standing or permission of department chairperson. K. Friedman

315. Advanced Reporting (3) fall
Planning, researching and writing in-depth news projects; investigative techniques; analyzing and interpreting social, political and economic trends. Prerequisite: Jour 214 or permission of the department chairperson. Lule

320. Journalism Proseminar (3) spring
Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: nine hours in journalism, public relations or communication or consent of the department chairperson. Hutton

323. Scientific and Environmental Controversies (3) spring
Research and writing on media reporting of controversial scientific and environmental topics. Public opinion polling; computer analysis and media databases. Prerequisite: Jour 11, Jour 123 or Jour 311 or consent of the department chairperson. S. Friedman

327. (SPsy 327) Mass Communication and Society (3)
A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of

selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Rosenwein

361. Internship (1-6) every semester
Professionally supervised work on commercial newspapers, magazines, radio and television stations, or with public relations and advertising organizations. Some internships involve science writing. May be repeated for a maximum of six credits. Prerequisite: Junior or senior standing and declared major or minor in journalism, science writing, public relations or communication and consent of the department chairperson. K. Friedman

Communication Courses

Comm 60. Fundamentals of Speech Communication (3)
The basic principles of communication: the informative speech, small group communication process, principles of persuasion, effects of mass communication. Two speeches, group project. Wills

Comm 130. Public Speaking (3) spring
Applying the principles of public speaking to making informative and persuasive presentations effectively. Emphasis on speech composition and effective oral communication skills.

Comm 143. Persuasion and Influence (3) fall
The social, symbolic, and rhetorical means of persuasion and how this persuasive influence is expressed in politics, advertising, and the mass media. Wills

Comm 144. Effective Interviewing (3) spring
Theory of effective interviewing; how to plan and structure an interview outline; types of questions used in interviews; how to open, conduct and conclude an interview. Special emphasis on the journalistic, employment and evaluation interview. Instructor will use role-playing and videotaping. Students will prepare and conduct simulated interviews. Wills

Comm 325. Special Topics in Communications (1-3)
Research and writing or performance involving a topic, medium or issue in journalism, public relations, speech or communication theory not covered in other courses. Prerequisite: nine hours in journalism, public relations or communication and consent of department chairperson.

Comm 331. Business and Professional Speaking (3) fall
The principles of oral communication as applied to business and professional situations. Professional presentations, small group interaction and interpersonal communication in the business setting. Prerequisite: junior or senior standing.

Languages

Courses are listed alphabetically under Modern Foreign Languages.

Latin American Studies

See listings under Modern Foreign Languages. See also International Careers, where an undergraduate may focus on Latin America as a geographical concentration.

Law and Business

Professor. Perry A. Zirkel, J.D., LL.M. (Yale), Ph.D. (Connecticut), *University Professor of Education and Law.*

Associate professors. George A. Nation III, J.D. (Villanova), *chairman*; Sue and Eugene Mercy, Jr., *Professor of Business and Economics*.

Assistant professor. Matthew A. Melone, J.D. (Pennsylvania), C.P.A.

The Department of Law and Business is responsible for the law program in the College of Business and Economics and participates in the Law and Legal Institutions program. Members of the Department provide pre-law advice for students in the College. A major program of studies is not offered.

Undergraduate Courses

11. Introduction to Law (3)

A study of the nature and function of law and the legal system, the study of legal reasoning through the use of the case method. Required first course in the Law and Legal Institutions minor program. Open only to freshmen and sophomores except with the consent of the coordinator of the program.

201. Legal Environment of Business (3) every semester

The study of the legal relationships of business and government, business and society and the individual and society. The case method is used to develop analytical skills. Introduction to contract law and the law of sales underlying the free market system. Prerequisite: Eco 11, Eco 12, and junior standing.

202. Business Law (3) every semester

The law of sales, contracts, agency, business organizations, secured transaction, property and negotiable instruments. Prerequisite: Law 201.

221. (Phil 221) Sex-Discrimination and the Law (3)

A critical study of the law of sex discrimination in areas of constitutional and labor law. A case approach that places emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. Lindgren

371. Directed Readings (1-3)

Readings in various fields of law, designed for students who have a special interest in a field of law.

372. Special Topics (3)

Special problems and issues in commercial law.

Graduate Courses

404. Legal Environment of Management (3)

The effect of public and private law on business decisions. The legal relationship of business and society and business and government, especially the government regulation of business. Introduction to contract law underlying the free market system.

406. The Legal Aspects of International Business

A study of the international legal environment of business. The problem method is used to analyze the differences, difficulties, and opportunities of international business. Topics to be studied include: importing and exporting goods, nontariff trade barriers, transfers of technology, foreign direct investment, and doing business in the EEC.

437. Federal Taxation and Business Decisions (3)

Impact of federal taxation on the structure and timing of business decisions. Problem-solving methods and research techniques from a managerial perspective. Not available to students with two or more courses in taxation. Prerequisite: a basic course in accounting.

Management

Professors. Richard W. Barsness, Ph.D. (Minnesota); Alden S. Bean, Ph.D. (Northwestern), *Kenan Professor of Management and Technology*; John W. Bonge, Ph.D. (Northwestern); Michael G. Kolchin, D.B.A. (Indiana); Benjamin Litt, Ph.D. (N.Y.U.); James W. Schmotter, Ph.D. (Northwestern), *dean of the College of Business and Economics*.

Associate professors. Peter P. Poole, Ph.D. (Penn State); Theodore W. Schlie, Ph.D. (Northwestern); John E. Stevens, Ph.D. (Cincinnati), *chairperson*.

Assistant professors. Susan A. Sherer, Ph.D. (Pennsylvania); Robert J. Trent, Ph.D. (Michigan State).

Instructor. Douglas D. Moesel, M.S. (Oklahoma State).

Lecturer. Dale F. Falcinella, M.B.A. (Lehigh).

Adjunct professors. L. Jack Bradt, B.S. (Cornell); Don S. Follett, M.S. (Cornell); Laurie Gostley-Hackett, M.S. (Lehigh); Mehdi Hojjat, Ph.D. (Lehigh); Dennis D. Newhart, MBA (Lehigh); James R. Seifert, M.S.E.E. (Lehigh); Kenneth Stott, Jr., Ph.D. (Lehigh); Judy A. Swartley, M.S., MBA (Lehigh).

Management Program and Courses

Each undergraduate management major will select either the *Specialization* (15 hours) or *Interfunctional* (18 hours) track shown below:

Specialization (15 hours)

required courses:

Mgt 302	Quantitative Models-Conceptual (3)
Mgt 321	Organizational Behavior Workshop (3)

*Plus at least one of the following:

Mgt 309	Industrial Purchasing and Materials Management (3)
Mgt 311	LUMAC Management Assistance Counseling (3)
Mgt 331	Industrial Relations and Public Policy (3)
Mgt 333	Personnel Management (3)

Up to two of the following:

Acct 324	Cost Accounting (3)
Eco 333	Managerial Economics (3)
Eco 334	Labor-Management Relations
Eco 335	Labor Economics (3)
Eco 352	Advanced Statistical Methods (3)
Eco 357	Econometrics (3)
Fin 328	Corporate Financial Policy (3)
Mkt 319	New Product Planning (3)
Mkt 321	Marketing in the Industrial Environment (3)
IE 309	Introduction to Information Systems (3)
IE 334	Organizational Planning and Control (3)
IE 332	Product Quality (3)

*Courses other than Mgt 302 and Mgt 321 will be selected in consultation with the faculty advisor to comprise one of the following specialization options: entrepreneurship, human resources management, materials management, and operations management.

Interfunctional (18 hours)

required courses:

Mgt 302	Quantitative Models-Conceptual (3)
Mgt 321	Organizational Behavior Workshop (3)
Acct 324	Cost Accounting (3)
Fin 328	Corporate Financial Policy (3)
Mkt 319	New Product Planning (3) or

Mkt 321	Marketing in the Industrial Environment (3)
Plus one of the following:	
IE 309	Introduction to Information Systems (3)
IE 334	Organizational Planning and Control (3)
IE 332	Product Quality (3)

Undergraduate Courses

Mgt 1. Introduction to Business Computing (3) fall and spring

A one-semester survey of computer technology and software applications in business and economics. Topics include introduction to computer architecture and logic, operating systems, spreadsheets, and data base management systems. Students will develop a working knowledge of microcomputers, mainframes and the campus-wide network. Limited to freshmen only. (Mgt. 1 will be a prerequisite for many courses in the College of Business and Economics.)

Mgt 101. (ECO 101) Introduction to Quantitative Methods (3)

Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics.

Mgt 175. Quantitative Methods

Topics from mathematics, statistics, and computers will be integrated and extended to develop analytical skills important to further studies and careers in business and economic. Emphasis on applications and problem solving. Topics include: multiple regression, sampling methodology, analysis of variance, chi-square tests, simulation, decision theory, network models, and optimization including linear programming. Prerequisites: Math 41 and 44, Mgt 1 and Eco 145.

Mgt 269. Management of Operations in Organizations (3) fall-spring

Design, operation and control of activities necessary to generate goods or services of profit and nonprofit organizations. Basic concepts and quantitative modes used in operations. Eco 145, Math 44. Sherer

Mgt 270. Organization Theory and Behavior (3) fall-spring

Formal organizations as ongoing systems. Emphasis is placed on the introduction of theory applicable to the management of human behavior in work environments. Issues at the individual, group, and organizational levels of analysis are addressed. Topics covered include motivation, stress, career processes, leadership, conflict management, decision making, work politics, organizational design, and organizational development. Poole

Mgt 301. Business Management Policies (3) fall-spring

Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the viewpoint of general management. Long-range goal attainment, policy formulation, and administrative implementation for specific functional areas and the total firm. Prerequisite: senior standing in the College of Business and Economics, and completion of the college core.

Mgt 302. Quantitative Models-Conceptual (3)

Quantitative methodologies and their use in business, economics and related areas. Classical optimization techniques, mathematical programming, linear programming, decision theory, game theory, simulation and network models. Prerequisites: Eco 105, Acct 111 and Mgt 269.

Mgt 306. Entrepreneurship and Business Policy (3) spring
Case study of problems in creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core, and Mgt 311, as well as approval of the department chairperson. Students may not receive credit for both Mgt 306 and Mgt 301. Bonge

Mgt 307. Business Communication Skills (3)

Written and spoken communication through letters, memos, reports, and oral presentations. Formal and informal communication networks, and communication processes. Prerequisite: consent of instructor.

Mgt 309. Industrial Purchasing and Materials Management (3)

Negotiating, purchasing, receiving, storing, inventory control, value analysis, procurement information systems, and specialized problems in institutional and government procurement. Lectures and cases. Prerequisite: Mgt 269 or equivalent. Kolchin

Mgt 311. LUMAC Management Assistance Counseling (3) fall-spring

A field studies course providing management assistance to small businesses in the Lehigh Valley. Students work in small groups under faculty supervision on a direct basis with owners. Problem solving and experience in applying marketing, accounting, finance, and/or management concepts to business. Prerequisites: junior standing in the College of business and Economics. Bonge, Stevens

Mgt 321. Organizational Behavior Workshop (3)

A workshop course examining individual behavior, interpersonal transactions and behavioral processes in small work groups through motivational analysis, role-playing nonverbal interactions, problem solving and group simulations. Prerequisites: Mgt 270 and permission of the department chairperson. Poole, Kolchin

Mgt 331. Industrial Relations and Public Policy (3)

An examination of the evolution and current status of U.S. public policy toward the organization and recognition of labor unions, collective bargaining, labor contract administration, and arbitration of disputes as expressed in federal statutes, court decisions, and National Labor Relations Board rulings. Stevens

Mgt 333. Personnel Management (3)

Analysis and resolution of personnel problems in organizations. Human resource planning, recruitment, selection, orientation, training, appraisal, compensation, and development. Lectures and cases. Prerequisite: Mgt 270. Kolchin

Mgt 371. Directed Readings (1-3)

Readings in various fields of management designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 372. Special Topics (1-3)

Special problems and issues in management for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

For Graduate Students

Mgt 401. Quantitative Methods in Business and Economics (3)

Management science methods and applications. Mathematical programming, simulation, decision theory,

game theory, network models and statistics. Prerequisite: Eco 401 or equivalent.

Mgt 409. Purchasing and Materials Management (3)

Overview of the purchasing and materials functions in organizations: Negotiation, buying, receiving, storing, inventory control, value analysis, legal aspects, and specialized problems in institutional and government procurement. Combination of lectures and case analyses. Kolchin

Mgt 413. Organizational Behavior and Management (3)

Interpersonal and group behavior in organizations. Issues of organization work and perception, motivation, communications, conflict, leadership, and organization structure. Kolchin, Litt, Poole

Mgt 423. Operations Management (3)

Capacity planning and aggregate scheduling, inventory theory including MRP and JIT, production scheduling, standards and quality control, and project management. Prerequisite: Mgt 401 (or equivalent). Sherer

Mgt 425. Human Resource Management (3)

A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, evaluation, compensation, career planning, safety and health. Kolchin

Mgt 429. Managerial Policy and Decision-Making (3) fall-spring

Integration of theory and analytic techniques through intensive investigation of complex organizational, strategic and financial problems in industrial and nonbusiness entities. Case studies. Prerequisite: graduate-level exposure to accounting, economics, finance, management and marketing. An MBA candidate should take the course near the end of the MBA program. Stevens

Mgt 430. (IE 430) Management Science Project (3)

As an individual or as a member of a small group, analysis of a management problem and the design of its solution is made incorporating management science techniques. An individual written report is required. Recommended that it be taken in the last semester of the M.S. in management science program.

Mgt 431. Organizational Design and Change (3) fall

Variables relevant to determining the design of structures and processes of organizations; techniques pertinent to organizational adaptation to changed environments, technologies and social factors. Prerequisite: Mgt 413. Bonge

Mgt 433. Corporate Enterprise: Concepts and Issues (3)

Examines issues relevant to modern corporate enterprises: managing technological innovation; role of public policy; management values-ethics and human resources. Barsness, Litt

Mgt 435. Organizational Decision Processes (3)

Examines individual responsibility and information handling styles in managerial decision-making processes in formal organizations. Negotiated decision-making, joint problem solving, and values based decision-making processes. Prerequisite: Mgt 413. Litt

Mgt 445. (IE 417) Advanced Mathematical Programming (3)

Theory and applications of the extensions of linear programming. Tucker-Kuhn conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

Mgt 447. Analytical Methods in Management (3)

Application of management science methods to industrial

and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing, and manufacturing.

Mgt 453. (MoT 453) Qualitative Research Methods (3)

Study of techniques that describe, decode, and translate social phenomena. Explores how interpretive researchers plan and conduct studies and present findings. Studies investigators' roles, data sources, observation methods, data analysis methods, and trustworthiness of findings. A field research project is required.

Mgt 455. Managerial Communication Skills (3)

Organization, style, and strategy of language to inform, direct, and persuade. Application of writing, reading, speaking, and listening skills to managerial problems. Case studies.

Mgt 457. Technology Management Seminar (3)

Review of current literature on technology management with emphasis on relation among business strategy, competitive conditions, management practice and the technological innovation process. Case studies and outside speakers. Critical analysis of research and application to technology management problems. Bean, Schlie

Mgt 467. (MoT 467) Strategic Information Systems (3)

Study of the impact of information technology on business strategy and the influence of information resources on competition. Explores development and management of competitive information systems strategy, including risks associated with investments in information systems technology. Case studies and applications include operations management, financial and accounting services, and marketing.

Mgt 471. Directed Readings (1-3)

Graduate readings in management not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 472. Special Topics (1-3)

Special problems and issues in management for which no regularly scheduled graduate coursework exists. When offered as group study, coverage will vary according to the interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 490. Thesis (1-3)

Management of Technology

Program director. Alden S. Bean, Ph.D. (Northwestern); Wm. R. Kenan, Jr. *professor of management and technology.*

Program faculty. Benjamin Litt, Ph.D. (NYU), *professor of management*; Peter P. Poole, Ph.D. (Penn State), *associate professor of management*; Manash R. Ray, Ph.D. (Penn State), *assistant professor of accounting*; Theodore W. Schlie, Ph.D. (Northwestern), *associate professor of management*; Susan A. Sherer, Ph.D. (Pennsylvania), *assistant professor of management*; E. Sarah Slaughter, Ph.D. (M.I.T.), *assistant professor of civil engineering*; Bruce M. Smackey, Ph.D. (Rensselaer), *professor of marketing*; John K. Smith, Ph.D. (Delaware), *associate professor of history*; Robert H. Storer, Ph.D. (Georgia Tech), *assistant professor of industrial engineering*; Todd Watkins, Ph.D. (Harvard), *assistant professor of economics*; Samuel C. Weaver, Ph.D. (Lehigh), *adjunct professor of finance*; John C. Wiginton, Ph.D. (Carnegie-Mellon), *professor of industrial engineering.*

The program requires 45 credit hours of graduate work, including a thesis. It is designed for students with undergraduate degrees in science or engineering and at least four years of work experience in industries

characterized by rapid technological change or whose firms compete on the basis of highly specialized knowledge. Students with undergraduate degrees in other fields will be considered based on employer recommendations and other qualifications.

The program may be taken on a part-time basis, typically requiring two courses per semester; or a "released-time" basis, requiring three courses per semester over five semesters; or as an accelerated full-time program that can be completed in a calendar year by taking five courses per semester, including the summer. Up to six credit hours may be taken from an approved list of courses available through the National Technological University's satellite TV network.

Required Coursework

Acct 413. Managerial Accounting and Decision-Making (3)
(A two-day financial accounting seminar offered during orientation will be accepted as the prerequisite for MOT students.)

Eco 472. Technology and Economic Analysis (3)
Theoretical and empirical bases for understanding the productivity effects of technological change in economic systems; relationships between technological change and industry structure; and applications of economic analysis to the effects of technological change in the firm. (This course is intended only for MOT students.)

Fin 411. Financial Management (3)
(Acct 413 and Eco 472 will be prerequisites for MOT students.)

Hist 446. Readings in the History of Technology (3)

Mot 421. Technology, Manufacturing, and Competitive Strategy (3)
Industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; manufacturing and technology strategy; manufacturing's contribution to competitive advantages in quality, cost, variety, and new product availability; segmentation, substitution, and vertical integration.

Mot 432. R, D, & E Project Management (3)
Management of cross-functional project teams for introducing technological innovations in the manufacturing and marketing of new products and services in a variety of industries.

Mot 436. Information Technology and Operations Management (3)
Operations management issues from the standpoint of information requirements, and how information technology may be deployed to meet those requirements.

Mot 440. R&D Management (3)
Developing R&D programs to achieve strategic business objectives; selecting, staffing, and managing R&D projects; and transferring research results to commercial functions.

Mot 450. Science and Technology Policies and Institutions (3)
The science and technology institutional infrastructure and its relationships with management decision-making, including: private, public (government), and quasi-public institutions; R&D, regulatory, and policy institutions; and U.S., foreign, and international institutions.

Mgt 453. Qualitative Research Methods (3)

Mgt 490. Thesis (3)

Elective Courses

Mgt 467. Strategic Information Systems (3)

Mkt 441. New Product Planning in Marketing and Research and Development (3)

Mot 477. Diffusion and Implementations of Technology (3)
Classical macro-study of adoption and diffusion of innovation, and managing the implementation/utilization/application of new technology in the organization/corporate culture.

Transfer Credits—Required and Elective

One or two of the following courses may be taken for transfer credit and applied toward the MOT program requirements. These courses originate at other universities and are broadcast via satellite to the Lehigh campus and several corporate sites in the area. Transfer credit will be arranged by Lehigh through the National Technological University (NTU).

Managing and Leading Technical Professionals (3)
This course, with NTU course designation MT 730, is *required* of all MOT candidates. Ideas on the most effective methods for increasing individual invention and organization innovation, including: motivation, leadership, technical communications, career development, group dynamics, organization design, and the impact of different organization forms and supervisory styles on individual and group performance.

Science Technology and International Business (3)
An *elective* with NTU course designation MT 742. Issues in international economic competitiveness, including: productivity and technological innovation, multinational corporations, technology transfer (public domain and proprietary), intellectual property rights, S&T in economic development, national S&T policies, international cooperative arrangements, and international organizations involved with S&T.

Quality Management (3)
An *elective* with NTU course designation MT 751. The U.S. Malcolm Baldrige National Quality Award criteria for measurement of quality excellence provides the focus for such topics as leadership, information and analysis, strategic quality planning, human resource utilization, quality assurance, results, and customer satisfaction.

Analyses of Emerging Technology (3)
An *elective* with NTU course designation MT 761. Technology forecasting/assessment methods, including: roadblocks, key leverage points, likely prospects, identification of potential impacts, implications for selected industries, and policy considerations.

Manufacturing Systems Engineering

Program director. Keith M. Gardiner, Ph.D. (Manchester, England), *professor of industrial engineering*.
Program faculty. Mikell P. Groover, Ph.D. (Lehigh), *MSF associate director, professor of industrial engineering*; Alden S. Bean, Ph.D. (Lehigh), *professor of management and technology*; Benjamin Litt, Ph.D. (N.Y.U.), *professor of management*; Roger N. Nagel, Ph.D. (Maryland), *Harvey E. Wagner Professor of manufacturing systems engineering*; John B. Ochs, Ph.D. (Penn State), *associate professor of mechanical engineering and mechanics*; Nicholas G. Odrey, Ph.D. (Penn State), *associate professor of industrial engineering*; Tulga Ozsoy, Ph.D. (Tech. Univ. of Istanbul), *associate professor of mechanical engineering and mechanics*; N. Duke Perreira, Ph.D. (California, Los Angeles), *associate professor of mechanical engineering and manufacturing systems engineering*; Richard Roberts, Ph.D. (Lehigh), *professor of mechanical engineering and mechanics*; Bruce M. Smackey, Ph.D. (Rensselaer), *professor of marketing*; Theodore Schlie, Ph.D. (Northwestern), *associate professor of management*; Robert H. Storer, Ph.D. (Georgia Tech.), *assistant professor of industrial engineering*; Marlin U. Thomas, Ph.D. (Michigan-Ann Arbor), *chairman and professor of*

industrial engineering; John C. Wiginton, Ph.D. (Carnegie-Mellon), *professor of industrial engineering*; George R. Wilson, Ph.D. (Penn State), *associate professor of industrial engineering*; David S. Wu, Ph.D. (Penn State), *assistant professor of industrial engineering*; Emory W. Zimmers, Jr., Ph.D. (Lehigh), *professor of industrial engineering*.

The graduate curriculum in MSE is designed to develop engineers who can design, install, operate and modify manufacturing systems which involve people, materials, processes, equipment, facilities, logistics, information systems and appropriate technology. The program integrates systems perspectives with interdisciplinary education and training.

The Program is offered on a full-time basis, with core courses beginning in January each year and is also available for students from industry on a partial release basis with classes one weekday evening and all day on Friday over a two-year period.

The 30 credit hour curriculum leads to a Master of Science degree. A series of weekly seminars, plant tours, tutorials and laboratory projects make up the non-credit program requirements.

Graduate Courses

398. Manufacturing Cost Management Systems (3)

This course studies a new approach to control of manufacturing costs based on the analysis of value-adding activities. Activity analysis, an extension of traditional work study, decomposes a company (or sub-unit) in to all of the major activities performed in producing goods or services, and relates them to their resource costs. This decomposition focuses on what triggers activities, and how the costs of these activities may be rolled up to cost products, product lines, or services to customers. These same cost data may be used for target costing, driving continuous improvement programs, and capital budgeting decisions. Wiginton

421. Managing the Manufacturing Life Cycle (3)

Manufacturing as an integrated technical-social-economic system. Linkages between corporate and manufacturing strategies. Combines a systems perspective with project leadership and membership skills for introducing and managing change into manufacturing systems at various life cycle stages.

423. Product Design/Analysis (3)

Integrated approach to design and analysis of products and systems. Principles for robust design and use of computer-aided engineering to model, evaluate, and enhance design. Case studies and design assignments.

425. Production Planning and Resource Allocation (3)

Capacity planning, scheduling, inventory control, and other topics in the management of manufacturing resources. Discrete and continuous simulation models for analysis and design of production systems. Factory information systems and data bases for computer integrated manufacturing.

427. Production Systems (3)

Modern production and assembly methods used in the mechanical and electrical/electronics industries. Techniques for deciding the most appropriate production method for a new product. Computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods.

431. Technological Innovation in the Manufacturing Organization (3)

Organizational issues and decision-making for capital investments in new technologies. The commercialization process is traced from research and development and marketing activities through the implementation phase involving the manufacturing function. Term project is a commercialization plan for a new manufacturing technology.

433. Technology and the Factory of the Future (3)

Engineering and technological issues affecting future developments in manufacturing. Topics include flexible automation systems, integration of design and production through the factory data network, intelligent machines, the man-machine interface, and the manufacturing management information system.

451. Manufacturing Systems Engineering Project (1-3)

490. Manufacturing Systems Engineering Thesis (1-6)

496. Microelectronics Manufacturing Systems & Technologies (3)

Manufacturing engineering in electronics manufacture: crystal growth, doping, thin film deposition technologies and tooling, pattern generation techniques, contamination control, clean room practices, microelectronics assembly and packaging. Examination of systems design and operation issues.

Marketing

Professor. Bruce M. Smackey, Ph.D. (Rensselaer), *chairperson*.

Associate professors. James E. Hansz, Ph.D. (Cincinnati); James M. Maskulka, D.B.A. (Kent State).

Assistant professors. Melinda Smith de Borrero, Ph.D. (South Carolina); Carolyn J. Simmons, Ph.D. (Florida).

Adjunct professor. Therese A. Maskulka, D.B.A. (Kent State).

Lecturer. Dale F. Falcinelli, M.S. (Lehigh).

Career Opportunities in Marketing

The field of marketing offers career opportunities for students in business, economics, liberal arts, engineering, and the physical sciences.

Marketing is pervasive in our society and is a critical function in the promotion of world trade. Creativity and the ability to conduct insightful analyses of competitive business situations are the hallmarks of a well-prepared student who can contribute to a prospective employer's organization. Undergraduates and graduates have been able to secure entry-level positions in a variety of marketing activities with firms in advertising and public relations, retail management, industrial sales and purchasing, bank marketing, marketing research, and new product design. Combining the marketing curriculum with related subjects in international relations, psychology and sociology, engineering, and history can often strengthen a student's capability to grow beyond his or her formal education period. Students are encouraged to explore the potential enhancement of their educational experience through study abroad programs, internships with business, and research projects with faculty members.

Participation in the Marketing Club student organization is an extracurricular activity that offers a professional orientation program and the enjoyment of socializing with other students from across the campus.

For undergraduates, the marketing major in the College of Business and Economics consists of fifteen credit hours from the following courses:

Required courses

Mkt 312	Marketing Research (3)
Mkt 313	Marketing Communications (3)

Elective courses

Three courses (nine credit hours) from the following:

Mkt 315	Consumer Behavior (3)
Mkt 316	Advertising (3)
Mkt 319	New Product Planning (3)
Mkt 320	International Marketing (3)
Mkt 321	Business to Business Marketing (3)
Mkt 330	Retail Management (3)
Mkt 371	Directed Readings (1-3)

Mkt 372. Special Topics (1-3)

Other approved courses may be used as marketing electives depending upon student's career orientation. The ability to double-major can be explored with the department chair or the student's advisor, as well as academic credit for internships.

For Advanced Undergraduates and Graduate Students

Mkt 211. Contemporary Marketing (3) fall-spring

The course examines contemporary marketing from a managerial perspective. Design of marketing programs within the context of consumer behavior, the social, economic, and cultural environment, market segmentation, demand, and industry structure. Prerequisite: Eco 1 or Eco 11 and 12.

Mkt 312. Marketing Research (3) fall-spring

Quantitative and qualitative information in routine and nonrecurring decision-making. Statistical design of marketing studies, model building, analysis of research studies, and the development of marketing information systems. Case problems and presentation of student research projects examine problems in communicating research results. Prerequisites: Eco 145 and Mkt 211. de Borrero and Simmons

Mkt 313. Marketing Communications (3) fall-spring

Communication-promotion decision processes of organizations. Impact of source, message and media variables on audience response to communication campaigns and the interactions among these variables. Role of personal selling, sales promotion, publicity, and advertising in marketing. Prerequisite: Mkt 211. de Borrero and Simmons

Mkt 315. Consumer Behavior (3)

Principal theories of psychology, social psychology, anthropology and economics which contribute to understanding the behavior and motivations of consumers. Consumer needs and wants; learning theory; the perceptual process; decision-making processes; communication; search behavior; market segmentation and product differentiation; and the adoption and diffusion of innovations. Prerequisite: Mkt 211 and Mkt 312. de Borrero and Simmons

Mkt 316. Advertising (3) spring

Analysis of advertising campaigns and the societal implications of advertising are considered from a managerial perspective. Prerequisite: Mkt 313. J. Maskulka

Mkt 319. New Product Planning (3) spring

Organization and management of marketing activities related to the development of new and improved products and services. The role of marketing research and product testing in the commercialization process. Application of risk analysis to the screening of ideas for new product candidates. Prerequisites: Mkt 211 and Fin 225. Smackey

Mkt 320. International Marketing (3) fall

The foreign market entry strategies firms may use are examined: export, contractual arrangements, and investment. Student companies implement each strategy in a multinational business game or through case analysis. Prerequisites: Fin 225 and Mkt 211. Hansz, J. Maskulka

Mkt 321. Business to Business Marketing (3)

The marketing of products and professional services from the firm to organizations; marketing principles applied to other than the ultimate customer in society; the role of salespersons as consultants to industrial customers and in professional fields such as banking, advertising, and management advisory services.

Mkt 330. Retail Management (3) fall

Full coverage of all major retailing topics including consumer behavior, marketing research, store location, service retailing, the retail audit, retail institutions, and

international retailing. Students work in groups to conceptualize and develop a retail store of their choice. Prerequisites: Mkt 211 and Mkt 312. T. Maskulka

Mkt 371. Directed Readings (1-3)

Readings in various fields of marketing designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mkt 372. Special Topics (1-3)

Special problems and issues in marketing for which no regularly scheduled coursework exists. When offered as group study or internship, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

For Graduate Students

Graduate students are encouraged to meet with the department chair to discuss their career interests and program planning before beginning formal graduate coursework.

Mkt 411. Marketing and the Global Firm fall

Emphasis is placed on understanding the process of globalization and its resultant impact on the firm's marketing function. Case analysis and/or computer simulations are employed to enhance the student's understanding of the challenges and opportunities facing the firm pursuing globalization. Prerequisite: Mkt 413. Hansz, J. Maskulka

Mkt 413. Marketing Management (3) fall-spring

Planning and managing marketing activities: market analysis, buyer behavior, market segmentation, marketing research, product policy and strategy, distribution channels policy, advertising, and sales force management. Prerequisite: Eco 408 (or concurrently). Hansz, J. Maskulka, Simmons

Mkt 433. Strategic Marketing (3)

Strategic issues facing corporations in a highly competitive and rapidly changing environment. Case studies and preparation of a strategic plan. Prerequisite: Mkt 413.

Mkt 435. Marketing Information and Decision-Making (3)

Obtaining relevant marketing information for decision-making is examined from two perspectives: special projects and information systems. Student projects. Prerequisite: Mkt 413. Hansz, Simmons

Mkt 437. Advertising Management (3) spring

Analysis of consumer and industrial advertising campaigns from a managerial perspective. Prerequisite: Mkt 413. J. Maskulka

Mkt 439. Industrial Marketing and Sales Management (3) fall

Marketing and sales problems associated with manufacturers of industrial products: organization and productivity of the sales force, product line policies, pricing strategies, buyer requirements, customer service, and formal bidding proposals. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 441. New Product Planning in Marketing and Research and Development (3) spring

The design, development and marketing of new products and processes in high technology industries; inventors and the importance of patents and licensing; generation and screening of ideas; commercialization term project. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 443. Buyer Behavior and Marketing Management (3)

Concepts, methodologies, and current research involving consumer and organizational buying behavior. Prerequisite: Mkt 413. de Borrero and Simmons

Mkt 445. Management of Sales Operations (3)

Planning and organizing strategic sales programs; developing the sales force through recruitment, training, and motivation; control of sales programs through performance evaluation of sales personnel; and integrating sales with other marketing activities. Prerequisite: Mkt 413.

Mkt 452. Causal Modeling (3)

This course brings together in a single analytical framework two longstanding traditions: simultaneous equation modeling (regression analysis) and factor analysis (measurement models). Topics covered include: measurement error, reliability, validity, confirmatory factor analysis, and latent variable modeling. Prerequisites: Intermediate statistical theory or consent of department chairperson.

Mkt 462. Research Methodology (3) spring, odd-numbered years

Criteria which distinguish scientific research from other significant human activities; development of concepts, laws and theories; general principles of research design; measurement theory; and scientific values and ethics. Students are expected to prepare a defensible dissertation proposal during the course. Open only to doctoral students. de Borrero and Simmons

Mkt 463. Advanced Data Analysis (3) spring, even-numbered years

Applications oriented analysis of variance, regression analysis, and multi-variate analysis. SPSS, BMD, and other computer packages are used to analyze empirical data. Prerequisite: Intermediate statistics or permission of department chairperson.

Mkt 471. Directed Readings (1-3)

Graduate reading in marketing not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the chairperson. May be repeated.

Mkt 472. Special Topics (1-3)

Problems and issues in marketing for which no regularly scheduled graduate coursework exists. When offered as group study or internship, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Materials Science and Engineering

Professors. David B. Williams, Ph.D. (Cambridge), *Harold Chambers Senior Professor, chairperson*; S. Kenneth Tarby, Ph.D. (Carnegie-Mellon), *associate chairperson*; Betzalel Avitzur, Ph.D. (Michigan), *director of Institute for Metal Forming*; Ye T. Chou, Ph.D. (Carnegie-Mellon), *New Century Professor*; Joseph I. Goldstein, Sc.D. (M.I.T.), *Stout Professor*; Martin P. Harmer, Ph.D. (Leeds, England), *Alcoa Professor, director of Materials Research Center*; Richard W. Hertzberg, Ph.D. (Lehigh), *New Jersey Zinc Professor*; Ralph J. Jaccodine, Ph.D. (Notre Dame), *Sherman Fairchild Professor*; Himanshu Jain, Engr. Sci. D. (Columbia); Charles E. Lyman, Ph.D. (M.I.T.); Arnold R. Marder, Ph.D. (Lehigh); Michael R. Notis, Ph.D. (Lehigh); Alan W. Pense, Ph.D. (Lehigh); *Provost*; Donald M. Smyth, Ph.D. (M.I.T.), *Paul B. Reinhold Professor*; David A. Thomas, Sc.D. (M.I.T.).

Associate professor. Helen M. Chan, Ph.D. (Imperial College of Science and Technology, England).

Assistant professors. Katy Barmak, Ph.D. (M.I.T.); Raymond A. Pearson, Ph.D. (Michigan).

Adjunct professors. Yung-Haw Hu, Ph.D. (Lehigh); Brian R. Lawn, Ph.D. (Western Australia); Gary A. Miller, Sc.D. (M.I.T.); Seymour Traub, J.D. (Georgetown).

Emeritus professors. Sidney R. Butler, Ph.D. (Penn State); George P. Conard II, Sc.D. (M.I.T.); Walter C. Hahn, Ph.D. (Penn State); R. Wayne Kraft, Ph.D. (Michigan); Robert D. Stout, Ph.D. (Lehigh); John D. Wood, Ph.D. (Lehigh). **Research engineers and scientists.** David W. Ackland; Arlan O. Benscoter; John DuPont, B.S. (Ohio State); Eric Kaufmann, Ph.D. (Lehigh).

As science and technology advance in the 1990s and beyond, progress in many fields will depend on the discovery and development of new materials, processed in more complex ways, and with new kinds of properties. This has recently been demonstrated nicely by the development of superconducting ceramic materials. It is widely recognized that the progress of history has been divided into periods characterized by the materials that mankind has used, i.e., the stone age, the bronze age, the iron age. Today, materials science and engineering is critical to all other fields of engineering, and advances in these other fields are often limited by advances in materials.

Interest in new materials for solid-state devices, space technology, and superconductivity, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in science and technology of materials.

Education for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies; these broaden the student's outlook and enhance professional development after graduation.

The undergraduate program is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in various specialties of the field, including the manufacture and applications of metals, ceramics, polymers, composites, and electronic materials. While some graduates go directly into materials-producing companies, a large proportion serve as engineers in the chemical, electrical, transportation, communications, space and other materials consumer industries. A number of students pursue graduate study leading to careers in research and teaching.

Major Requirements

The recommended sequence of courses is shown below. The standard freshman engineering year is shown on page 34.

sophomore year, first semester (16 credits)*

Math 23	Analytic Geometry & Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
Eco 11	Principles of Microeconomics (3) or
Eco 12	Principles of Macroeconomics (3)
Mat 33	Engineering Materials and Processes (3) or
HSS	Humanities/Social Sciences Elect (3)
Mat 10	Materials Laboratory (1)

*Mat 10 and Mat 33 are required and should normally be taken during the sophomore year. However, they may be taken in the first semester of the junior year.

sophomore year, second semester (16 credits)

Math 205	Linear Methods (3) or
ECE 81	Principles of Electrical Engineering (4)
Mech 2	Elementary Engineering Mechanics (3)
HSS	Humanities/Social Sciences Elect (3)
Mat 33	Engineering Materials and Processes (3) or

HSS	Humanities/Social Sciences Elect (3)
junior year, first semester (17 credits)	
Mat 101	Professional Development (2)
Elect.	Elective (3)
Chem 209	Chemistry of Materials (3)
Mat 203	Structure and Characterization of Materials (3)
Mat 205	Thermodynamics and Phase Diagrams (3)
ChE 60	Unit Operations Survey (3)
junior year, second semester (18 credits)	
Mat 204	Processing and Properties of Polymeric Materials (3)
Mat 206	Processing and Properties of Metals (3)
Mat 214	Processing and Properties of Ceramic Materials (3)
Mat 216	Diffusion and Phase Transformations (3)
Mat 218	Mechanical Behavior of Materials (3)
Elect.	Elective (3)
senior year, first semester (18 credits)	
Mat 201	Physical Properties of Materials (3)
Mat 301	Design and Selection of Engineering Materials (3)
Mat 303	Macroprocessing of Materials (3)
Engr. Sci. Elect.	Engineering Science Elective (3)**
HSS	Humanities/Social Sciences Elect (3)
IE 111	Engineering Probability and Statistics (3) or
Math 231	Probability and Statistics (3)
senior year, second semester (18 credits)	
Mat 302	Electronic Properties of Materials (3)
Mat 338	Materials Reports (3)
Engr.Sci.Elect.	Engineering Science Elective (3)**
HSS	Humanities/Social Sciences Elective (3)
Elect.	Elective (3)
Approved. Elect.	Approved Elective (3)**
**For the approved electives and/or engineering science electives, two courses should be taken from one of the following five specialization categories:	
(1) Metals	
Mat 305	Ferrous Production Metallurgy
Mat 312	Fundamentals of Corrosion
Mat 314	Advanced Metal Forming
Mat 317	Imperfections in Crystals
Mat 344	Materials Joining Methods
(2) Ceramics	
Mat 315	Physical Properties of Structural and Electronic Ceramics
Mat 335	Principles of Semiconductor Materials Processing
Mat 342	Inorganic Glasses
Mat 348	Materials Science for Electronic Applications
Mat 396	Chemistry of Nonmetallic Solids
(3) Polymers	
Mat 343	Physical Polymer Science
Mat 388	Polymer Synthesis and Characterization Lab
Mat 309	Composite Materials

(4) Industrial Option*	
Mat 327	Industrial Project (4)
Mat 329	Industrial Project (4)

(5) Research Option**	
Mat 240	Research Techniques (3)
Mat 291	Undergraduate Research (3)

*The industrial option is designed to prepare students as plant materials engineers. The emphasis in Mat 327 and 329 is a team approach to the solution of actual plant problems. The courses are conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems. The option is limited to a small group of seniors, selected by the department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

**For those students who may be interested in research or development, and intend to pursue graduate work, a research option is offered. In this option, students take Mat 240 and 291. Financial support may be available for those students who elect to initiate a research program during the summer preceding the senior year. The option is limited to a small group of selected students.

Undergraduate Courses

10. Materials Laboratory (1) fall

Introduction to experimental methods used to fabricate and measure the structure and properties of materials. Thermal and mechanical processing and properties are emphasized. Specimen preparation and examination by optical microscopy. Prerequisite: Mat 33 previously or concurrently.

33. Engineering Materials and Processes (3) fall-spring

Application of physical and chemical principles to understanding, selection, and fabrication of engineering materials. Materials considered include metals, polymers, ceramics, composites and electronic materials. Case studies of materials used range from transportation systems to microelectronic devices. Staff

101. Professional Development (2) fall

Seminar on the role and purpose of engineering in society; the meaning of being a professional; the role of creativity, communications and decision making in the engineering process; expectations and problems of young engineers; personal goals; choosing a career. Required reading. Written reports based on library research. Prerequisite: junior standing.

107. Special Topics in Materials (1-3)

A study of selected topics in materials science and engineering not covered in other formal courses.

192. Structural Materials (3) fall

The major classes of materials—metals, ceramics and concrete, polymers, and composites—with emphasis on their suitability for structural applications. The dependence of material properties on atomic bonding, microstructure, processing, and service conditions. Some laboratories on determination of mechanical properties. Required for civil engineering students. Prerequisite: Mech 12. Hertzberg

For Advanced Undergraduates and Graduate Students

201. Physical Properties of Materials (3) fall

Basic concepts of modern physics and quantum mechanics needed for an understanding of electrons in solids. The experimental development leading to wave mechanics is emphasized. Uses of the Schrodinger equation as the basis for the free electron theory of metals and band theory. Optical properties are developed leading to a discussion of lasers. Prerequisite: Phys 21, Mat 33, Math 205. Physics 31 may be substituted. Notis

203. Structure and Characterization of Materials (3) fall

Atomic structure and types of bonding. Crystalline and amorphous states. Crystal structures, and fundamental aspects of crystallography (space lattice, Miller indices, symmetry elements). Crystal defects (point, line and planar). Basic principles of structure determination by x-ray diffraction. Microscopical techniques (light and electron optical), and their application to material characterization. Prerequisite: Chem 21; Mat 10 and Mat 33 previously or concurrently. Chan, Lyman, Notis, Williams

204. Processing and Properties of Polymeric Materials (3) spring

The structure-property relationships in polymers will be developed, emphasizing the glass transition, rubber elasticity, crystallinity, and mechanical behavior. Elements of polymer processing. Extrusion of plastics and films, and fiber spinning operations. Lectures and laboratories. Prerequisite: Chem 209 or one semester of organic chemistry. Thomas, Pearson

205. Thermodynamics and Phase Diagrams (3) fall

The three laws of thermodynamics. Gibbs free energy and thermodynamic basis for equilibrium. Solution thermodynamics. Binary and ternary equilibrium phase diagrams. Application of thermodynamics to materials problems. Lectures and laboratories. Prerequisite: Math 23 and Mat 33 or equivalent. Tarby, Notis

206. Processing and Properties of Metals (3) spring

The production and purification of metals, their fabrication, and control of their properties. Includes topics such as precipitation hardening, hot and cold working, and casting. Lectures and laboratories. Prerequisite: Mat 205. Marder

213. Materials Systems Analysis (3)

Study of application of materials science principles to the solution of materials engineering problems. Interrelation between basic concepts and the selection of complete materials systems, which consist of the fabricating process and finishing sequence, for particular design requirements. Materials covered will be metals, polymers, ceramics and composites. Not open to materials majors. Lectures and laboratory. Prerequisite: Mat 33 or equivalent.

214. Processing and Properties of Ceramic Materials (3) spring

General overview of the compositions, properties and applications of ceramic materials. The theory and practice of fabrication methods for ceramics and glasses. Methods of characterization. Selected properties of ceramic materials. Lectures and laboratories. Prerequisite: Mat 33, Chem 209. Harmer, Chan

216. Diffusion and Phase Transformations (3) spring

Fundamental diffusion equations; liquid-solid transformations; solid-solid transformations; transformation kinetics; metastable transformations; diffusionless transformations; examples of various transformations in different materials and their effect on properties. Prerequisite: Mat 203, Mat 205. Williams, Notis

218. Mechanical Behavior of Materials (3) spring

Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from microstructural and fracture mechanics viewpoints. Fatigue failure. Prerequisites: Mech 2, Mat 203, and Mat 33. Hertzberg

221. (STS 221) Materials in the Development of Man (3)

Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering

students may not use this course for engineering science or technical elective credit. Notis

240. Research Techniques (3)

Study and application of research techniques in materials science and engineering. Research opportunities, design of experimental programs, analysis of data, presentation of results. Selection of research topic and preparation and defense of research proposal. Restricted to a small number of students selected by the department from those who apply.

291. Undergraduate Research (3)

Application of research techniques to a project in materials science and engineering selected in consultation with the faculty. Normally preceded by Mat 240.

301. Design and Selection of Engineering Materials (3) fall

Review of ceramics, metals, plastics and composites as engineering materials. Analysis of design requirements for material components. Selection of materials with appropriate fabrication, thermal and surface finish processing to solve specific engineering problems. Lectures plus laboratory which includes individual designing and conducting original experiments to solve materials engineering problems. Prerequisite: Mat 204, Mat 206, Mat 214, Mat 218, and concurrently Mat 303. Thomas

302. Electronic Properties of Materials (3) spring

The electronic structure of materials, i.e., band and zone theory, is presented from a physical point of view. Electrical conductivity in metals, semiconductors, insulators and superconductors is discussed. Simple semiconductor devices reviewed. Magnetic properties are examined in the context of domain theory and applications are discussed. Optical and dielectric properties of semiconductors and ferroelectrics are considered. Prerequisite: Mat 33, Mat 201, Mat 203. Jain, Notis

303. Macroprocessing of Materials (3) fall

Basic concepts of stress, strain and stress-strain behavior during plastic flow. Yield criteria and approximations to the experimental stress-strain curve. Work and power of deformation. Description and analysis of numerous forming processes. Additional concepts as: friction, hydrodynamic lubrication, forming of metallic and nonmetallic composite materials, and pressure induced ductility. Avitzur

305. Ferrous Production Metallurgy (3)

A detailed engineering analysis of iron and steel making processes. Thermodynamic and kinetic aspects of these processes. Development of mathematical models of processes by computer programming. Lectures, laboratory, and plant trips. Prerequisite: Mat 205. Tarby

309. Composite Materials (3)

The principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers. Lectures and some field trips or laboratories. Prerequisite: Mat 33 or equivalent, Mech 2. Thomas

310. Independent Study in Materials (1-3)

Provides an opportunity for advanced, independent study of selected topics in materials science and engineering not covered in other formal courses.

311. Metallic Materials for Structures (3)

The structure and behavior of structural steels, aluminum and other alloys, with emphasis on materials used in large-scale engineering structures such as bridges, buildings and pressure vessels. Fracture mechanics concepts, the physical metallurgy of alloys involved, and fabrication of structures, especially welding. The relationship between materials, fracture control and fabrication. Materials majors may take only with the consent of the department chairperson. Lectures and laboratory. Prerequisite: Mat 33 or 92 or consent of instructor. Hertzberg

312. (ChE 312, Chem 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Mat 205, Chem 187, or equivalent of either. Barmak

314. Advanced Metal Forming (3)
Extension of Mat 303. Topics to be included: friction, lubrication and wear, failure and damage in metal forming, and deformation in composite metals and in powder metallurgy. Forming alternatives for specific products such as cans, tubes, wires and others will be compared. Recent developments of new forming processes. Prerequisite: Mat 303. Avitzur

315. Physical Properties of Structural and Electronic Ceramics (3)

Structure-property relationships in ceramics. Mechanical behavior including plasticity, hardness, elasticity, strength and toughening mechanisms. Thermal behavior including specific heat, thermal expansion, thermal conduction and thermal shock. Electrical behavior including application of tensors and crystal physics to electroceramics. Prerequisites: Mat 214 or consent of instructor. Harner

317. Imperfections in Crystals (3)

The major types of crystal defects and their role in controlling the properties of materials. Point, line and planar defects, their atomic configurations and experimental techniques to study their characteristics. Emphasis on the role of dislocations and grain boundaries in the control of mechanical properties. Prerequisite: Mat 203 or consent of instructor. Chou, Williams

319. Current Topics in Materials Science (3)

Selected topics of current interest in the field of materials engineering but not covered in the regular courses. May be repeated for credit with consent of the department chairperson. Prerequisite: Consent of department chairperson.

320. Analytical Methods in Materials Science (3)

Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, diffusion. Prerequisite: Math 231 or 205. Chou

323. (ECE 303) Electrical and Physical Characterization of Defects in Semiconductors

Basic concepts of solid-state physics applied to p-n junction theory. Topics will include influence of material growth techniques on defect origination; dislocations induced by diffusion; oxidation-induced stacking faults; the role of imperfections on pipe leakage and soft breakdowns. The relation of materials, defects and processing will be highlighted. Jaccodine

327. Industrial Project (4) fall

Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent on development projects at the plant of an area industry, under the direction of a plant engineer and with faculty supervision. Tarby, Chan

329. Industrial Project (4) fall

To be taken concurrently with Mat 327. Course material is the same as Mat 327.

333. (Geol 337, Chem 337) Crystallography and Diffraction (3)

Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections,

orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisites: Mat 203 or Geol 133 or senior standing in chemistry. Lyman, Chan

334. (Geol 338) Electron Microscopy and Microanalysis (4) fall

Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. Williams, Lyman

335. (ChE 335) Principles of Semiconductor Materials Processing (3)

Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modelling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: a course in thermodynamics and senior standing. Jaccodine

338. Materials Reports (3) spring

Written and oral communication through various types of reports and talks. Evaluation on both technical content and quality of presentation. Use of information sources, graphics, and visual aids. Videotaping and peer critique of oral presentations. Prerequisite: senior standing.

342. Inorganic Glasses (3)

Definition, formation and structure of glass; common glass systems; manufacturing processes; optical, mechanical, electrical and dielectric properties; chemical durability; glass fibers and glass ceramics. Lectures and laboratories. Prerequisite: Mat 33. Jain, Chan

343. (ChE 393, Chem 393) Physical Polymer Science (3)

Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry.

344. Materials Joining Methods (3)

The processes by which materials may be joined, including fusion and solid-state welding, brazing, adhesive bonding and mechanical fastening. Effects of the joining processes on the service properties, particularly of high-performance materials and of dissimilar materials. The basis for the selection and evaluation of joining processes. Case studies and demonstrations. Prerequisite: Mat 33. Staff

345. Nondestructive Evaluation (3)

Scientific fundamentals and engineering applications of nondestructive evaluation methods including penetrant, magnetic particle, eddy-current, radiographic, ultrasonic and acoustic-emission inspection techniques. Recent developments in nondestructive inspection of materials. Lectures and labs. Prerequisite: Mat 33 or equivalent, senior standing.

347. Microprocessing of Materials (3)

Discussion of methods developed to fabricate single crystals, thin films and coatings. Topics include; crystal growth, physical and chemical deposition processes, patterning and microlithography, chemical and physical methods of material removal, surface modification and coating

processes. Connection between processing, structure (defects) and properties is emphasized. Prerequisite: senior standing. Jaccodine

348. Materials Science for Electronic Applications (3)
Materials technology for integrated circuit packaging systems. Dielectric, thermal and mechanical considerations; joining methods; resistor and ceramic capacitor materials and incorporation of active devices into packaging systems; multilayer package design and processing. Individualized semester project involving forensic examination of failures using scanning electron microscopy and microprobe analysis. Prerequisite: Mat 201, and Mat 33. Notis

388. (ChE 388, Chm 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chm 51, 187 or 191.

396. (Chem 396) Chemistry of Nonmetallic Solids (3)
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interaction. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Mat 205 or equivalent. Smyth

For Graduate Students

The department offers three degrees; a master of science, a master of engineering, and a doctor of philosophy in science and materials engineering.

While a diversity of programs and curricula are available to a person interested in graduate study in the area of materials, generally the degree is earned in the department of materials science and engineering. However, thesis and dissertation research may be a part of programs under way in the department or at the Materials Research Center or other departments or centers.

The department has a large enough staff and graduate enrollment to enable it to suit the needs of students whose interests range from the science of materials through materials engineering. At the same time, those advanced students who want experience in teaching are able to teach under the guidance of the senior staff.

The foundation for successful graduate work in the department includes sound preparation in chemistry, physics and mathematics, and adequate breadth of general education. Candidates entering the department who have obtained their previous degrees in fields other than materials may be required to take certain undergraduate courses without credit toward the graduate degree.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty adviser. Under the adviser's direction, the student plans a course of study to satisfy individual needs and interests.

Most advanced-degree recipients find careers in industry or industrial or governmental research and development laboratories. A smaller number have gone into teaching, consulting or academic research.

Graduate facilities for research are located in the Whitaker Laboratory, in the interdisciplinary Materials Research Center, the Sherman Fairchild Laboratory, and other associated laboratories. The laboratories are well equipped with both generalized equipment as well as sophisticated research equipment.

Specialized equipment such as conventional and scanning transmission electron microscopes, scanning electron microscopes, electron microprobe, X-ray diffraction units, closed-loop mechanical testing equipment, and crystal-growing and zone-processing equipment are maintained and operated by skilled technicians. After

receiving the required instructions, graduate students operate this equipment.

Departmental facilities are supplemented by central computer facilities, microcomputers, and a fine science and engineering library.

Special Programs and Opportunities

The department has established specific recommended programs for the M.S., the M.Eng., and the Ph.D., emphasizing the following areas: electron microscopy and microanalysis of all materials, physical metallurgy, ceramics, polymers and composites, mechanical behavior, electronic materials, and manufacturing processes.

These programs are flexible. Students in an area such as fracture may work in the department or in cooperation with the Materials Research Center or the department of mechanical engineering. The ceramics program emphasizes the study of the electrical and mechanical behavior of various ceramic systems. The study of solid-state materials for electronic applications is done largely in the Sherman Fairchild Laboratory. The department also cooperates with the chemical engineering and chemistry departments in the graduate Polymer Science and Engineering Program.

Major Requirements

The Graduate School requirements are explained in Section IV. In the department of materials science and engineering, a candidate for the M.S. completes a thesis. This normally represents six of the thirty semester hours required for this degree. Candidates for the M.Eng. complete a three-credit engineering project.

A candidate for the Ph.D. prepares a preliminary program of courses and research, providing for specialization in some phase of the field (largely through research) in consultation with the adviser. Prior to formal establishment of the doctoral program by the special committee and its approval by The Graduate School, the student passes a qualifying examination that must be taken early in the first year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships and assistantships are available. This type of aid generally provides for tuition, an allowance for experimental supplies, and a stipend. For details of graduate scholarships, fellowships and assistantships, please refer to Section IV.

Research Activities

Graduate students conduct their research in facilities located in the department or the Materials Research Center, or other centers and institutes. The following list of activities notes the many areas of interest. Asterisks (*) indicate research of an interdisciplinary nature.

Materials science. Crystal growth*; defect chemistry and electrical properties of insulating and semiconducting oxides*; growth and deformation of bicrystals; dislocation studies; meteorites and lunar materials; processing of metal insulator semiconductor structures and their evaluation and application to integrated circuits*; quantitative metallography; structure and behavior of solid-state materials.*

Mechanical behavior. Correlation of microstructure with mechanical behavior of low-alloy, high-strength steels; deep drawing, impact extrusion and ironing; electron fractography*; environmental crack kinetics*; fatigue crack propagation studies of metals and polymers*; flow through converging conical dies; friction measurement; theoretical analysis of metal-forming methods and correlation with metallurgical parameters; toughness of weld metal; weldability of steels.

Ceramics. Electrical properties of electronic ceramics*; hot pressing studies*; grain growth in oxides*; electrical and

magnetic properties of oxides*; creep modeling of ceramics*; electron microscopy of dislocation structures*; defect chemistry and electrical properties of ceramic oxides and glasses*; deformation and fracture of structural ceramics and ceramic composites.*

Physical metallurgy. Brittle fracture characteristics and fatigue properties of low-alloy, high-strength steels*; diffusion-controlled growth; kinetics of solid-state reactions*; physical metallurgy of aluminum alloys; strengthening mechanisms; structure and morphology of martensite; ternary diffusion; transformation during joining; transmission electron microscopy of crystal defects.

Polymers. Environmental effects on polymers*; fatigue crack propagation in engineering plastics*; fracture surfaces of crystalline polymers*; ion transport in polymer membranes; mechanical behavior of interpenetrating networks*; mechanical behavior of polyvinyl chloride*; micromechanics of polymer fracture*; polymers from renewable resources; properties of polymer composites*; reclamation of scrap polymeric materials*; viscoelastic damping.

Chemical metallurgy. Mathematical modeling of metallurgical processes; thermodynamics of metallic solutions; thermodynamics and phase equilibria.

Electronic materials. Origin and properties of defects in semiconductors and insulators; processing of materials used in VLSI device structures, processes studied include ion implantation, rapid thermal processing, chemically enhanced oxidation, LPCVD, sputtering, and plasma etching and deposition.

Graduate-Level Courses

Mat 401 Thermodynamics and Kinetics I (3) fall

Integrated treatment of the fundamentals of thermodynamics, diffusion and kinetics, as related to materials processes. Coverage of topics in classical and statistical thermodynamics including the laws of thermodynamics, conditions of equilibrium, and thermodynamics of phase transitions. Atomistic description of diffusion. Influence of concentration/potential gradients and effects of temperature and pressure.

Mat 402 Thermodynamics and Kinetics II (3) spring

Continuation of Mat 401. Derivation of fundamental diffusion equations, and their application to single and multicomponent systems. Theoretical models of nucleation and growth (including spinodal decomposition), and comparison with experimental observations. Kinetics of solid state transformations, including phase transformations and particle coarsening.

Mat 403 Structure and Properties I (3) fall

The underlying principles of the structure of materials and relationship to properties. Mathematical foundations such as applications of partial differential equations, and group theory and tensor properties. Crystal structure including symmetry, point and space groups, and crystal symmetry and properties. Study of recent reviews and classic sources.

Mat 404 Structure and Properties II (3) spring

Continuation of Mat 403. Defects in crystals in relationship to properties, including point, line, and planar defects. Non-crystalline structure including covalent-ionic, metallic, and polymeric glasses; related concepts such as short-range order and fractal geometry. Concludes with student presentations on important topics from Mat 403 and 404.

406. Solidification (3)

Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results. Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional super-cooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the chairperson.

408. Transformations (3) fall

The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second-phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in non-metals. Prerequisite: Mat 205 and 216 or equivalent. Marder

409. Current Topics in Materials (3)

Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chairperson.

410. Physical Chemistry of Metals (3)

Discussions of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilibria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experimentation and computation. Prerequisite: Mat 205 or equivalent. Tarby

411. Modern Joining Methods (3)

The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisite: Mat 216 and 218 or equivalent. Pense

412. Magnetic Properties of Materials (3)

Fundamental concepts of magnetism and magnetic properties of ferro- and ferrimagnetic materials. Metallic and nonmetallic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent. Notis, Barmak

413. Analysis of Metal Forming Processes (3)

Three-dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem. Avitzur

415. Mechanical Behavior of Ceramic Solids (3)

Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multi-component brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: Mat 218 or consent of the department chairperson. Notis, Harmer

416. Atom Movements (3)

Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisite: Math 23 and Chem 196 or the equivalent.

417. Deformation and Strength of Solids (3)

Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: Mat 218 or equivalent. Chou, Hertzberg, Notis

418. Fatigue and Fracture of Engineering Materials (3) fall

Application of fracture mechanics concepts to the fatigue and fracture of crystalline and amorphous solids. Fracture control design philosophies. Metallurgical aspects of fracture toughness and embrittlement susceptibility. Environment-enhanced cracking. Fatigue crack propagation in metals and polymers. Electron fractography. Failure analysis case histories. Prerequisite: Mat 218 or equivalent. Hertzberg

419. Advanced Physical Metallurgy (3)

Application of physical metallurgy principles to materials systems. Transformation structures and the influence of morphology on properties. Alloy design and heat treatment for improved strength, toughness, creep, corrosion resistance, electrical and magnetic properties. Prerequisite: Mat 301 or equivalent. Marder

421. Fracture Analysis (3)

Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: Mat 218 or 311 or Mech 313 or equivalent. Hertzberg and Traub

423. Advanced Transmission Electron Microscopy (4)

The theory and practice of operation of the transmission and scanning transmission electron microscope. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: Mat 334 or equivalent. Williams

425. Topics in Materials Processing (3)

Topics such as: ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition and ultra-high-purity materials preparation. Desirable preparation: Mat 204 or 206 or 214, and Mat 218. Prerequisite: consent of the department chairperson.

427. Advanced Scanning Electron Microscopy (4)

The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: Mat 334 or equivalent.

429. Dielectric and Electrical Properties of Ceramics (3)

Basic concepts of dielectric and electrical phenomena in ceramics including dielectric loss, dielectric breakdown, ferroelectricity, piezoelectricity, mixed conduction, and interfacial effects. Physical and materials aspects of technologically important ceramics such as thermistors, varistors, boundary layer capacitors, solid electrolytes, gas sensors, glasses etc. Prerequisite: Mat 201 or equivalent. Jain

430. Glass Science (3)

Definition and formation of glass. Structure of common inorganic (including metallic) and polymeric glass systems. Methods of glass making. Phase separation of devitrification. Physical properties including diffusion, electrical conductivity, chemical durability, and optical and mechanical properties. Special products including glass ceramics, optical fibers, photosensitive glasses, etc. Visit to a glass manufacturing plant may also be included. Prerequisite: Mat 315 or equivalent. Jain

431. Sintering Theory and Practice (3)

Science and technology of the sintering of solid state materials. Driving force and variables. Critical review of the sintering models. Coverage of single phase, multiphase and composite systems. Special sintering techniques such as fast firing, rate controlled sintering, hot pressing and transient second phase sintering. Sintering of specific ceramic and metal systems. Prerequisite: Mat 214 or equivalent. Harmer

432. Theories of Silicon Oxidation (3)

A critical review is given of advanced theories of silicon oxidation. Present accepted theory (Deal-Grove) is inadequate for explaining thin (state-of-the-art <200 Å) oxides. Course will consider most recent approaches to theory of thin gate insulators. It will also include new

experimental approaches that use "impurity gaseous doping" and halogen additions. Jaccodine

437. (Mech 437) Dislocations and Strength in Crystals (3)

Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisite: Math 205 or 231, or Mat 320; Mat 317, or consent of the department chairperson. Chou, Wei

443. (Chem 443) Solid-State Chemistry (3)

Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: Chem 191 or equivalent. Klier

458. Materials Design (3)

Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chairperson. Thomas

460. Engineering Project (1-3)

In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the M.Eng. May be repeated for a total of three credit hours. Thomas

461. Advanced Materials Research Techniques (3)

Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chairperson.

482. (Chem 482, ChE 482) Engineering Behavior of Polymers (3) spring

A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

485. (Chem 485, ChE 485) Polymer Blends and Composites (3) fall

An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent.

Mathematics

Professors. Edward F. Assmus, Jr., Ph.D. (Harvard); Donald M. Davis, Ph.D. (Stanford); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Jacob Y. Kazakia, Ph.D. (Lehigh); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky); Gregory T. McAllister, Ph.D. (Berkeley), *head of the Division of Applied Mathematics and Statistics*; George E. McCluskey, Ph.D. (Pennsylvania), *head of the Division of Astronomy*; Eric P. Salathe, Ph.D. (Brown), *director of the Institute for Biomedical Engineering and Mathematical Biology*; Murray Schechter, Ph.D. (N.Y.U.); Gerald F. Smith, Ph.D. (Brown); Andrew K. Snyder, Ph.D. (Lehigh), *chairperson*; Gilbert A. Stengle, Ph.D. (Wisconsin).

Associate professors. Bruce A. Dodson, Ph.D. (S.U.N.Y. at Stony Brook); Vladimir Dobric, Ph.D. (Zagreb, Yugoslavia); Wei-Min Huang, Ph.D. (Rochester); David L. Johnson, Ph.D. (M.I.T.); Clifford S. Queen, Ph.D. (Ohio State); Penny D. Smith, Ph.D. (Polytechnic Institute of Brooklyn); Lee J. Stanley, Ph.D. (Berkeley); Susan Szczepanski, Ph.D. (Rutgers); Ramamirtham Venkataraman, Ph.D. (Brown); Joseph E. Yukich, Ph.D. (M.I.T.).
Assistant professors. Garth Isaak, Ph.D. (Rutgers); Terrence Napier, Ph.D. (M.I.T.).

Mathematics is the universal language of science, and is essential for a clear and complete understanding of virtually all phenomena. Mathematical training prepares a student to express and analyze problems and relationships in a logical manner in a wide variety of disciplines including the physical, engineering, social, biological, and medical sciences, business, and pure mathematics itself. This is a principal reason behind the perpetual need and demand for mathematicians in education, research centers, government, and industry.

The department offers three major programs leading to the degrees of bachelor of arts in mathematics, bachelor of science in mathematics, and bachelor of science in statistics. It also offers five minor programs for undergraduates.

The Division of Astronomy and the Division of Applied Mathematics and Statistics are parts of the Department of Mathematics. Details on these divisions may be found in separate listings in the catalog.

Calculus Sequences

There are three calculus sequences: Math 21, 22, 23; Math 31, 32; Math 41, 44. The first sequence should be taken by those students who might go into engineering, mathematics or the natural and physical sciences. The first sequence will always be accepted in place of Math 41 and 44, but not vice versa. Math 41, 43 and 44 are designed primarily for students of the biological, management, and social sciences (BMSS); Math 44 should normally be taken in the semester following Math 41, but Math 43 may be taken at any time. Math 31 and 32 constitute an accelerated calculus sequence that is at least equivalent to the Math 21, 22, 23 sequence. Enrollment in Math 31 and 32 is limited to those students who have demonstrated exceptional ability in pre-university mathematics. A grade of B- or better in Math 31 is required to continue with Math 32. A grade of C- or better in Math 32 entitles a student to receive twelve credit hours for eight hours of work in Math 31 and 32. Credit will be awarded for only one course in each of the following three groups, A: 21, 31, 41, B: 22, 32, 44, C: 23, 32, when more than one course is taken in any group, credit will be given for the course with the maximum hours.

B.A. in Mathematics

The B.A. program in mathematics emphasizes fundamental principles as well as the mastery of techniques required for the effective use of mathematics. The program has the flexibility and versatility needed to prepare students for careers in government, industry and education. The program provides a solid foundation for those who want to pursue advanced study in any mathematically oriented field.

The program involves a total of 121 credit hours, 42 of which are in required major courses listed below. The remaining 79 credit hours are for college and university requirements, general electives, and additional mathematics courses that a student may wish to take.

Required Major Courses (42 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Math 205	Linear Methods (3) or
Math 320	Ordinary Differential Equations (3)
Math 219, 220	Principles of Analysis I and II (6)
Math 243	Algebra (3)
Math 244	Linear Algebra (3)
Math 316	Complex Analysis (3) or
Math 208	Complex Variables (3)
Math	Electives (12)

Note: Math 21, 22, 23 may be replaced by Math 31, 32. The twelve hours of electives must be approved by the student's major advisor. A student must achieve an average of 2.0 or higher in major courses.

B.S. in Mathematics

There are two programs that lead to the degree of Bachelor of Science in Mathematics: a General Mathematics Option and an Applied Mathematics Option. The former is recommended for students who wish to pursue mathematics in combination with a related field (such as physics, computer science or economics). The latter provides a broad background in the major areas of applicable mathematics. A student participating in the program is enrolled in the mathematics department. The programs involve a total of 121 credit hours, and each is divided into four parts. A student must achieve an average of 2.0 or higher in major courses.

Each student is assigned a faculty advisor to guide an individual program and supervise the choice of electives.

General Mathematics Option

College and University Requirements (37 credit hours) See page 25.

Required Major Courses (40 credit hours)

Math 21, 22, 23	Calculus and Analytic Geometry (12)
	or
Math 31, 32	Honors Calculus (12)
CSc 11	Introduction to Structured Programming (3) and
CSc 15	Data Structures (4) or
Eng 1	Engineering Computations (3) and
CSc 17	Structured Programming and Data Structures (4)
Math 12	Statistical Methods or
Math 231	Probability and Statistics (3)
Math 205	Linear Methods (3)
Math 208	Complex Variables or
Math 316	Complex Analysis (3)
Math 219	Principles of Analysis I (3)
Math 220	Principles of Analysis II (3)
Math 243	Algebra (3)
Math 244	Linear Algebra (3)

Major Electives (12 credit hours) Four courses with specific mathematical content chosen with the approval of the faculty advisor.

Electives (32 credit hours) These are to be selected with the approval of the faculty advisor to include at least 15 credit hours from at least two fields of application.

Applied Mathematics Option

College and University Requirements (37 credit hours) See page 25.

Required Major Courses (46 credit hours)

Math 21, 22, 23	Calculus and Analytic Geometry (12)
	or
Math 31, 32	Honors Calculus (12)
CSc 11	Introduction to Structured Programming (3) and
CSc 15	Data Structures (4) or
Eng 1	Engineering Computations (3) and
CSc 17	Structured Programming and Data Structures (4)
Math 12	Statistical Methods or
Math 231	Probability and Statistics (3)
Math 205	Linear Methods (3)
Math 208	Complex Variables or
Math 316	Complex Analysis (3)
Math 219	Principles of Analysis I (3)
Math 230	Numerical Methods (3)
Math 243	Algebra (3) or
Math 261	Discrete Structures (3)

Math 244	Linear Algebra (3)
Math 320	Ordinary Differential Equations (3)
Math 322	Methods of Applied Analysis I (3)

Major Electives (12 credit hours)

Four courses with specific mathematical content chosen with the approval of the faculty advisor.

Electives (26 credit hours)

These are to be selected to include a field of application with the approval of the faculty advisor.

B.S. in Statistics

Statistics is concerned with the development and application of techniques for collecting, analyzing and interpreting data in such a way that the reliability of the conclusions can be quantified. Statistical analysis thus forms a fundamental tool in all experimental sciences and is important in understanding chance phenomena. Mathematical principles, especially probability theory, underlie all statistical analyses.

The program involves a total of 121 credit hours, which are divided into four parts.

College and University Requirements (37 credit hours) See page 25.

Required Major Courses (43 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Math 12	Statistical Methods (3)
Math 205	Linear Methods (3)
Math 309	Theory of Probability (3)
Math 310	Probability and Its Applications (3)
Math 312	Applied Statistics (3)
Math 334	Mathematical Statistics (3)
Math 338	Regression Analysis (3)
Math 374	Statistical Project (3)
CSc 11	Introduction to Structured Programming (3)
CSc 15	Data Structures (4)

Note: Math 21, 22, 23 may be replaced by Math 31, 32, and Math 12 may be replaced by Math 231. A student must achieve an average of 2.0 or higher in major courses.

Major Electives (12 credit hours)

Four courses chosen from: Math 208, 219, 230, 244, 344, 1E 221, 222, 316, 332.

Professional Electives (29 credit hours)

These are to be selected from at least two fields of application of statistics and probability, such as biology, psychology, social relations, computer science, engineering, economics, and management.

The major and professional electives must be approved by the faculty advisor.

Minor Programs

The department offers five minor programs in different branches of the mathematical sciences. The minors are designed to provide recognition to those students who take a program of study in mathematics or a related area in addition to their major requirements in the engineering, arts and science or business curricula.

Each program requires twelve credit hours of work shown below, and Math 23 or 32. For substitutions, the student should consult the chairman.

Minor in Pure Mathematics

Math 219, 243, 244
Math 220 or 303 or 307 or 316 or 342

Minor in Applied Mathematics

Math 205 or 244
Math 208, 322
Math 230 or 231 or 320 or 323 or 344

Minor in probability and Statistics

Math 12 and 309, or Math 6 and 231, or Math 231 and 309
Any two of Math 310, 312, 334, 338

Minor in Actuarial Science

Math 205, 230, 231
Math 309 or 334 or 344

For information on examinations of actuarial societies, students may consult their minor advisor.

Minor in Astronomy

Phys 21, Astr 2
Astr 211 or 221
Astr 232 or 242

Undergraduate Courses**0. Precalculus (0)**

Review of the elementary mathematics needed to study calculus. No academic credit. Usually offered in the summer.

5. Introduction to Mathematical Thought (3) spring

Meaning, content, and methods of mathematical thought illustrated by topics that may be chosen from number theory, abstract algebra, combinatorics, finite or non-Euclidean geometries, game theory, mathematical logic, set theory, topology.

6. Introduction to Probability (3) spring

Random phenomena, events, probability spaces; counting methods, conditional probability, independence; random variables and their probability laws; hypergeometric, binomial and Poisson distributions; uniform, exponential and normal densities. Applications to various fields.

9. Introduction to Finite Mathematics (3) fall

Systems of linear equations, matrices, introduction to linear programming. Sets, counting methods, probability, random variables, introduction to Markov chains.

12. Statistical Methods (3) fall

Statistical data and frequency distributions; random sampling; estimation, confidence intervals, hypothesis testing; correlation, regression; analysis of variance. Illustrations from biological, social, physical and engineering sciences.

21. Analytic Geometry and Calculus I (4) fall-spring

Functions and graphs; limits and continuity; derivative, differential, and applications; Taylor's Theorem and other approximations; indefinite and definite integrals; trigonometric, logarithmic, exponential, and hyperbolic functions.

22. Analytic Geometry and Calculus II (4) fall-spring

Applications of integration; techniques of integration; separable differential equations; infinite sequences and series; curves and vectors in the plane. Prerequisite: Math 21 or Math 31.

23. Analytic Geometry and Calculus III (4) fall-spring

Vectors in space; partial derivatives; Lagrange multipliers; multiple integrals; vector analysis; exact differential equations and second-order differential equations with constant coefficients. Prerequisite: Math 22.

31. Honors Calculus I (4) fall

Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integrals, logarithmic; exponential, trigonometric and hyperbolic functions; techniques and applications of integration. Math 31 may be used in place of Math 21 to satisfy prerequisites. Prerequisite: consent of the department chairman.

32. Honors Calculus II (4) spring

Vector calculus; solid analytic geometry; series; Taylor's Theorem; approximations; partial derivatives; multiple integrals; line and surface integrals; differential equations.

Prerequisite: Math 31 or consent of the department chairman.

41. BMSS Calculus I (3) fall-spring

Functions including the exponential, logarithmic, and trigonometric functions; limits; continuity; differentiation with applications to maximum and minimum problems; antidifferentiation.

43. BMSS Linear Algebra (3) fall

Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming.

44. BMSS Calculus II (3) fall-spring

Indefinite and definite integrals and the fundamental theorem of calculus with applications; numerical integration; elementary differential equations; functions of several variables and partial derivatives with applications to extremal problems. Prerequisite: Math 41 or Math 21 or consent of the department chairman.

171. Readings (1-3) fall-spring

Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chairman.

For Advanced Undergraduates and Graduate Students

For students who have not taken their elementary mathematics at Lehigh, the prerequisites for certain advanced courses are stated in terms of the number of credit hours of calculus.

202. Problem Solving (1)

Practice in solving problems using calculus, linear algebra, probability, and statistics. Problems taken from actuarial examinations and mathematics contests. Prerequisites: Math 205 and Math 231 or consent of the department.

205. Linear Methods (3) fall-spring

Linear differential equations and applications; matrices and systems of linear equations; vector spaces; eigenvalues and application to linear systems of differential equations. Prerequisite: Math 23 or Math 32 or nine semester hours of differential and integral calculus.

207. (ChE 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall

Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205.

208. Complex Variables (3) fall-spring

Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math 23 or Math 32.

219. Principles of Analysis I (3) fall

Existence of limits, continuity and uniform continuity; Heine-Borel Theorem; existence of extreme values; mean value theorem and applications; conditions for existence of the Riemann integral; absolute and uniform convergence; emphasis on theoretical material from the calculus of one variable. Prerequisite: Math 23 or Math 32.

220. Principles of Analysis II (3) spring

Continuation of Math 219. Functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219.

230. Numerical Methods (3) fall

Representation of numbers and rounding error; numerical solution of equations; quadrature; polynomial and spline interpolation; numerical solution of initial and boundary

value problems. Prerequisites: Math 205 (previously or concurrently) and knowledge of either FORTRAN or PASCAL.

231. Probability and Statistics (3) fall-spring

Probability and distribution of random variables; populations and random sampling; chi-square, t, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: Math 23 or Math 32 or Math 44.

243. Algebra (3) spring

Introduction to basic concepts of modern algebra; groups, rings, and fields.

244. Linear Algebra (3) fall

Thorough treatment of the solution of m simultaneous linear equations in n unknowns, including a discussion of the computational complexity of the calculation. Vector spaces, linear dependence, bases, orthogonality, eigenvalues. Application as time permits. Prerequisite: Math 43 or Math 205 or Math 243.

261. (CSc 261) Discrete Structures (3)

Topics in discrete mathematical structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Prerequisites: Math 21, and either CSc 11 or Engr 1.

303. Mathematical Logic (3) fall

A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics.

304. Axiomatic Set Theory (3) spring

A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: Math 219 or consent of the department chairman.

307. General Topology I (3) fall

An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces. Prerequisite: Math 219.

309. Theory of Probability (3) fall

Probabilities of events on discrete and continuous sample spaces; random variables and probability distributions; expectations; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological sciences. Prerequisite: Math 23 or Math 32 or Math 44.

310. Probability and Its Applications (3) spring

Continuation of Math 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks. Prerequisite: Math 309 or consent of the department chairman.

312. Applied Statistics (3)

Exploratory data analysis; Monte Carlo methods; randomization and resampling. Computational aspects based on software tools and statistical packages. Prerequisite: Math 12 or Math 231.

316. Complex Analysis (3) spring

Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping. Prerequisite: Math 219.

320. Ordinary Differential Equations (3) spring

The analytical and geometric theory of ordinary differential

equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems. Prerequisite: Math 205, or both Math 23 and Math 244.

322. Methods of Applied Analysis I (3) fall

Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: Math 205 or consent of the department chairman.

323. Methods of Applied Analysis II (3) spring

Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math 322.

325. Computational Matrix Theory (3)

Numerical matrix algebra; algorithms for solving linear systems; symmetric and non-symmetric eigenvalue problems; least squares; functions of matrices. Students will apply these methods using either FORTRAN or PASCAL. Prerequisites: Math 205 or Math 244, and knowledge of FORTRAN or PASCAL.

327. Groups and Rings (3) fall

An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings. Prerequisite: Math 243 or consent of the department chairman.

329. Recursive Functions and the Theory of Computation (3)

Core development of classical recursion theory, enumeration, index and recursion theorems, using a simple programming language as a model of computation. Other models of computation and Church's Thesis. Recursive operators and their fixed points.

334. Mathematical Statistics (3) spring

Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypotheses. Prerequisite: Math 231 or Math 309.

338. Regression Analysis (3) spring

Least square principles in multiple regression and their interpretations; estimation, hypothesis testing, confidence and prediction intervals; residual analysis, multicollinearity, selection of regression models; comparison of data sets, analysis of variance and covariance, simultaneous inference procedures. Use of computer packages for statistical analysis. Prerequisite: Math 12 or 231.

340. (CSc 340) Design and Analysis of Algorithms (3) spring

Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching and fast Fourier transforms. Abstract complexity measures and the intrinsic complexity of algorithms and problems in terms of asymptotic behavior; correctness of algorithms. Prerequisites: Math 23 and CSc 15, or consent of the department chairman.

341. Mathematical Models and Their Formulation (3) spring

Mathematical modelling of engineering and physical systems with examples drawn from diverse disciplines such as traffic flow, laser drilling, mold solidification, rocket design and business planning. Prerequisite: Math 205.

342. Number Theory (3)

A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell's equation, Fermat's conjecture,

partitions. Prerequisite: Math 219 or consent of the department chairman.

347. Problem Solving (1) fall-spring

Emphasis on problems in analysis, linear algebra, and applications. May be repeated for credit with consent of the department chairman. Prerequisites: Math 219 and Math 244.

350. Special Topics (3) fall-spring

A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

371. Readings (1-3) fall-spring

The study of a topic in mathematics under appropriate supervision, designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

374. Statistical Project (3)

Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chairman.

Graduate Programs in Mathematics

The department offers graduate programs leading to the degrees of master of science in mathematics and the doctor of philosophy in mathematics.

To begin graduate work in mathematics a student must present evidence of adequate undergraduate preparation. The undergraduate program should have included a year of advanced calculus, a semester of linear algebra, and a semester of abstract algebra.

M.S. in Mathematics

The master's program demands thirty credit hours of graduate courses with at least eighteen hours at the 400 level. With the permission of the chairman, up to six hours of these courses can be replaced by a thesis. All students in the master's program must also pass a comprehensive examination.

With a judicious choice of courses a student in the master's program can specialize in pure mathematics, applied mathematics, or statistics. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

Ph.D. in Mathematics

The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student's command of some of the following areas: analysis, functional analysis, algebra, combinatorial theory, geometry, topology, probability, statistics, logic, numerical analysis, and differential equations. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

The department accepts candidates for the Ph.D. who desire to specialize in any of the areas listed above. Each candidate's plan of work must be approved by a special committee of the department. Although there are no specific course requirements, the Ph.D. candidates normally take several courses related to their area of specialization.

Graduate Programs in Applied Mathematics

See program description on page 50.

Graduate Courses

401. Real Analysis I (3) fall

Set theory, real numbers; introduction to measures, Lebesgue measure; integration, general convergence theorems; differentiation, functions of bounded variation, absolute continuity; L^p spaces. Prerequisites: Math 220 or consent of department chairman.

402. Real Analysis II (3) spring

Metric spaces; Introduction to Banach and Hilbert space theory; Fourier series and Fejer operators; general measure and integration theory, Radon-Nikodym and Riesz representation and theorems; Lebesgue-Stieltjes integral. Prerequisites: Math 307 and Math 401.

404. Mathematical Logic (3)

Topics in quantification theory relevant to formalized theories, recursive functions, Gödel's incompleteness theorem; algorithms and computability.

405. Partial Differential Equations I (3) fall

Classification of partial differential equations; methods of characteristics for first order equations; methods for representing solutions of the potential, heat, and wave equations, and properties of the solutions of these equations; maximum principles. Prerequisite: Math 220 or its equivalent.

406. Partial Differential Equations II (3) spring

Continuation of Math 405. Emphasis on second order equations with variable coefficients and systems of first order partial differential equations. Prerequisite: Math 405.

407. Theory and Technique of Optimization (3)

Linear programming; simplex and revised simplex methods, duality theory; unconstrained optimization by one dimensional search methods; convexity and Kuhn-Tucker conditions, applications to methods for constrained optimization.

408. Algebraic Topology I (3)

Polyhedra; fundamental groups; simplicial and singular homology.

409. Mathematics Seminar (1-6) fall

An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chairman.

410. Mathematics Seminar (1-6) spring

Continuation of the field of study in Math 409 or the intensive study of a different field. Prerequisite: consent of the department chairman.

414. Topics in Ordinary Differential Equations (3)

Topics from the analytical and qualitative theory of differential equations and dynamical systems such as: structural stability, ordered chaos and strange attractors, bifurcation theory, normal forms, asymptotic methods, spectral theory of differential operators, boundary value problems. Prerequisite: consent of the department chairperson.

416. Complex Function Theory (3) fall

Continuation of Math 316. Prerequisite: Math 316 or consent of the department chairman.

419. Linear Operators on Hilbert Space (3)

Algebra and calculus of bounded and unbounded operators on Hilbert space; spectral analysis of self-adjoint, normal, and unitary operators. Interplay between operator theory and classical function theory is emphasized. Prerequisites: Math 220, and Math 208 or Math 316.

423. Differential Geometry I (3)

Differential manifolds, tangent vectors and differentials, submanifolds and the implicit function theorem. Lie groups and Lie algebras, homogeneous spaces. Tensor and exterior algebras, tensor fields and differential forms, de Rham cohomology, Stoke's theorem, the Hodge theorem. Prerequisite: Math 219, 220, or Math 243 or Math 244 or Math 205 with consent of instructor.

424. Differential Geometry II (3)

Curves and surfaces in Euclidean space; mean and Gaussian curvatures, covariant differentiation, parallelism, geodesics, Gauss-Bonnet formula. Riemannian metrics, connections,

sectional curvature, generalized Gauss-Bonnet theorem. Further topics. Prerequisite: Math 423.

428. Fields and Modules (3) spring

Field theory, including an introduction to Galois theory; the theory of modules, including tensor products and classical algebras. Prerequisite: Math 327.

430. Numerical Analysis (3) spring

Multistep methods for ordinary differential equations; finite difference methods for partial differential equations; numerical approximation of functions. Use of computer required. Prerequisite: Math 230 or consent of the department chairman.

431. Calculus of Variations (3)

Existence of a relative minimum for single and multiple integral problems; variational inequalities of elliptic and parabolic types and methods of approximating a solution. Prerequisite: Math 220 or its equivalent.

435. Functional Analysis I (3) fall

Banach spaces and linear operators; separation and extension theorems; open mapping and uniform boundedness principles; weak topologies; local convexity and duality; Banach algebras; spectral theory of operators; and compact operators. Prerequisites: Math 307 and Math 401.

436. Functional Analysis II (3) spring

Continuation of Math 435. Topics such as distribution theory, nonlinear operators, fixed point theory and applications to classical analysis. Prerequisite: Math 435.

443. General Topology II (3)

Continuation of Math 307, with such topics as filters and nets, topological products, local compactness, paracompactness, metrizability, uniformity, function spaces, dimension theory. Prerequisite: Math 307.

444. Algebraic Topology II (3)

Continuation of Math 408. Cohomology theory, products, duality. Prerequisite: Math 408.

445. Topics in Algebraic Topology (3)

Selected topics reflecting the interests of the professor and the students. Prerequisite: Math 444.

449. Topics in Algebra (3)

Intensive study of topics in algebra with emphasis on recent developments. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairman.

450. Special Topics (3) fall-spring

Intensive study of some field of the mathematical sciences not covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairman.

453. Function Theory (3)

The development of one or more topics in function theory, such as analytic continuation, maximum modulus principle, conformal representation, Taylor series analysis, integral functions, Dirichlet series, functions of several complex variables. Prerequisite: Math 416.

455. Topics in Number Theory (3)

Selected topics in algebraic and analytic number theory. Prerequisites: Math 316 and Math 327. May be repeated for credit with consent of the department chairman.

461. Topics in Mathematical Statistics (3)

An intensive study of one or more topics such as theory of statistical tests, statistical estimation, regression, analysis of variance, nonparametric methods, stochastic approximation, and decision theory. Prerequisites: Math 334 and Math 401. May be repeated for credit with consent of the department chairman.

462. Nonparametric Statistics (3)

Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Smirnov tests for goodness of fit; the two-sample problem; confidence and tolerance intervals. Prerequisite: Math 231 or 309.

463. Advanced Probability (3)

Measure theoretic foundations; random variables, integration in a measure space, expectations; convergence of random variables and probability measures; conditional expectations; characteristic functions; sums of random variables, limit theorems. Prerequisites: Math 309 and Math 401.

464. Advanced Stochastic Processes (3)

Theory of stochastic processes; stopping times; martingales; Markov processes; Brownian motion; Skorohod imbedding; Brownian bridge, laws of suprema; Gaussian processes. Prerequisites: Math 309 and Math 401.

471. Homological Algebra (3)

Modules, tensor products, categories and functors, homology functors, projective and injective modules. Prerequisite: Math 428.

472. Group Representations (3)

Linear representations and character theory with emphasis on the finite and compact cases. Prerequisite: Math 428 or consent of the department chairman.

490. Thesis**499. Dissertation**

Mechanical Engineering and Mechanics

Professors. Robert P. Wei, Ph.D. (Princeton), *chairman*; Robert G. Sarubbi, Ph.D. (Lehigh), *assistant chairman*; Sunder H. Advani, Ph.D. (Stanford), *dean, College of Engineering and Physical Sciences*; Russell E. Benner, Ph.D. (Lehigh); Philip A. Blythe, Ph.D. (Manchester, England); Forbes T. Brown, Sc.D. (M.I.T.); Terry J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); D. Gary Harlow, Ph.D. (Cornell); Ronald J. Hartranft, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Edward K. Levy, Sc.D. (M.I.T.), *director, Energy Research Center*; Alister K. Macpherson, Ph.D. (Sydney, Australia); Sudhakar Neti, Ph.D. (Kentucky); John Ochs, Ph.D. (Penn State); Jerzy A. Owczarek, Ph.D. (London, England); Richard Roberts, Ph.D. (Lehigh); Donald O. Rockwell, Ph.D. (Lehigh); Kenneth N. Sawyers, Ph.D. (Brown), *Associate Dean, College of Engineering and Applied Science*; George C.M. Sih, Ph.D. (Lehigh), *director, Institute for Fracture and Solid Mechanics*; Charles R. Smith, Ph.D. (Stanford); Gerald F. Smith, Ph.D. (Brown); Theodore A. Terry, Ph.D. (Lehigh); Dean P. Updike, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); Arkady Voloshin, Ph.D. (Tel-Aviv, Israel); J. David A. Walker, Ph.D. (Western Ontario, Canada).
Associate professors. Meng-Sang Chew, Ph.D. (Columbia); Antonios Liakopoulos, Ph.D. (Florida); Robert A. Lucas, Ph.D. (Lehigh); Tulga M. Ozsoy, Ph.D. (Istanbul, Turkey); N. Duke Perreira, Ph.D. (California, Los Angeles).
Assistant professor. John P. Coulter, Ph.D. (Delaware)

Engineering is a creative profession aimed at satisfying needs of society through the combination of material, human and economic resources. The programs in Mechanical Engineering and in Engineering Mechanics are designed so that students will be ready upon graduation to pursue satisfying and productive careers in a wide variety of fields. Separate degree programs are offered leading to the

degrees of Bachelor of Science in Mechanical Engineering or Bachelor of Science in Engineering Mechanics.

Graduates in either degree are equipped for work in engineering, research and development and in government service or industry. Those with ability and interest have the necessary background to pursue further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as industrial engineering, chemical engineering, materials engineering, and biology, into interdisciplinary programs that will prepare them for further work in the areas of manufacturing, nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering, or biomechanics.

Undergraduates become thoroughly familiar with Lehigh's computer-aided design (CAD) laboratory. The laboratory is a *teaching* facility and the technology is regarded as an engineering tool that can be applied to solving a wide variety of problems. Undergraduates not only use CAD in their coursework but some have developed interactive tutorials that help fellow students expand on and clarify material presented in class.

B.S. in Mechanical Engineering

Mechanical Engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport and the control of motions and forces.

Mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water, and noise pollution. Some concentrate on the design of mechanical systems used in transportation, manufacturing or health care industries or by individual consumers. Some will be working, a decade from now, in fields that do not yet exist. Most will be engaged with concepts involving all four dimensions, space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences, and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences) with exposure to laboratory, the design process, computer-aided analysis and design, and specific applications fields. Much of the latter occurs in four or more courses elected toward the end of the program from a variety of offerings, which are identified by 300-level course designations. Courses in mechanical engineering and engineering mechanics are equally available.

The course requirements for B.S. degree in Mechanical Engineering are listed below. In addition to required Mathematics, Physics, Chemistry and basic engineering courses, the program includes 24 credits of humanities/social sciences (page 35), two free electives and four approved electives. The total graduation requirement is 131 credits.

Undergraduate Curriculum in Mechanical Engineering

freshman year (see page 34)

sophomore year, first semester (16 credit hours)	
Math 23	Analytic Geometry & Calculus III (4)
Mech 2	Elementary Engineering Mechanics (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
ME 10	Graphics for Engineering Design (4)

sophomore year, second semester (16 credit hours)	
Math 205	Linear Methods (3)
ME 104	Thermodynamics I (3)
Mech 12	Strength of Materials (3)
ME 21	Mechanical Engineering Lab I (1)

Mat 33	Engineering Materials and Processes (3)
Eco 11	Principles of Microeconomics (3) or
Eco 12	Principles of Macroeconomics (3)

junior year, first semester (18 credit hours)

Mech 102	Dynamics (3)
ME 205	Thermodynamics II (3)
ME 231	Fluid Mechanics (3)
ECE 81	Principles of Electrical Engineering (4)
ME 111	Professional Development (1)
ME 121	Mechanical Engineering Lab II (1)
HSS	Humanities/Social Sciences (3)

junior year, second semester (18 credits)

ME 101	Mechanical Engineering Design I (2)
ME 151	Mechanical Elements (3)
ECE 162	Electrical Laboratory (1)
ME 240	Manufacturing (3)
ME 242	Mechanical Vibrations (3)
Math 208	Complex Variables (3) or
Math 231	Probability and Statistics (3)
HSS	Humanities/Social Sciences (3)

senior year, first semester (16 credit hours)

ME 207	Mechanical Engineering Laboratories III (2)
ME 102	Mechanical Engineering Design II (2)
ME 321	Introduction to Heat Transfer (3) approved elective (3)
HSS	Humanities/Social Sciences (3) elective (3)*

senior year, second semester (17 credit hours)

ME 208	Mechanical Engineering Lab IV (2) or
ME 210	Laboratory Projects (2) approved electives (9)
HSS	Humanities/Social Sciences (3) elective (3)*

*Please refer to description of personal electives, page 35.

Twelve credits of *APPROVED ELECTIVES* must be taken according to the following distribution.

At least one course (3 credits) from the following list of *engineering science electives*:

ME 322	Gas Dynamics (3)
ME 331	Advanced Fluid Mechanics (3)
ME 343	Control Systems (3)
Mech 302	Advanced Dynamics (3)
Mech 305	Advanced Mechanics of Materials (3)

At least two courses (6 credits) from the following list of elective courses having *design or manufacturing content*:

ME 310	Directed Study (1-3)
ME 312	Synthesis of Mechanisms (3)
ME 323	Reciprocating and Centrifugal Engines (3)
ME 340	Advanced Mechanical Design (3)
ME 341	Mechanical Systems (3)
ME 342	Dynamics of Engineering Systems (3)
ME 345	Fluid Power (3)
ME 348	Computer-Aided Design (3)
ME 360	Nuclear Reactor Engineering (3)

Any design or manufacturing course taken outside of Mechanical Engineering must be approved by the student's advisor.

Other approved elective courses in the Department of Mechanical Engineering and Mechanics are:

ME 387	Digital Control (3)
Mech 307	Mechanics of Continua (3)

Mech 312	Finite Element Analysis (3)
Mech 313	Fracture Mechanics (3)
Mech 326	Aerodynamics (3)

Undergraduate Courses in Mechanical Engineering

ME 10. Graphics for Engineering Design (4) fall
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, production drawings, and 3-D solid geometric representation. Creation, storage, and manipulation of such graphical descriptions using state-of-the-art, commercially available, computer-aided engineering software. Introduction to design process through design projects. Geometrical design consideration of various manufacturing processes. Lectures and laboratory.

ME 21. Mechanical Engineering Laboratory I (1) fall, spring
Laboratory methods employed in mechanical engineering and mechanics. Planning and execution of experiments, analysis of data, and writing of reports. Introduction to elementary instrumentation. Prerequisite: Mech 12, previously or concurrently.

ME 101. Mechanical Engineering Design I (2) spring
Industry-based design projects. Design methodology, feasibility study of design alternatives. Oral and written communications. Prerequisites: ME 10, Mech 12, ME 104, and ME 210.

ME 104. Thermodynamics I (3) fall, spring
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and probability. Properties of pure substances and thermodynamic cycles. Prerequisites: Math 23 and Phys 11.

ME 111. Professional Development (1) fall
Examination of ethical and professional choices facing mechanical engineers.

ME 121. Mechanical Engineering Laboratory II (1) fall, spring

A continuation of ME 21 including use of transducers, advanced instrumentation, and data acquisition. Emphasis on experimental exercises that illustrate, and/or introduce material from thermodynamics, and fluid mechanics lecture courses. Includes proposal writing and interpretation of results. Prerequisites: ME 21 and ME 104.

ME 201. Mechanical Engineering Design II (2) fall
Industry-based design projects continued from ME 101. Design, analysis, and simulation by student teams. Fabrication, assembly, and testing of prototypes when practical. Oral and written reports required. Prerequisite: ME 101, ME 252, ME 121.

ME 205. Thermodynamics II (3) fall, spring
Availability and Second Law Analysis. Design of gas and vapor power cycles, and refrigeration systems. Generalized property relations for gases and gas-vapor. Combustion and chemical equilibrium. Design of engineering systems and processes incorporating thermodynamic concepts and analysis. Prerequisite: ME 104.

ME 207. Mechanical Engineering Laboratories III (2) fall
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results.

ME 208. Mechanical Engineering Laboratories IV (2) spring
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results.

ME 210. Laboratory Projects (1-2) fall, spring
Experimental work including planning, design and development of apparatus, data collection and analysis as it pertains to an engineering problem. Progress is reported in the form of several planning and project reports.
Prerequisite: Consent of department chairperson.

ME 240. Manufacturing (3) spring
Analytical and technological base for several manufacturing processes and common engineering materials. Processes include metal cutting, metal deformation, injection molding, thermoforming, and composites. Process planning, computer-aided manufacturing, manufacturing system engineering, and quality measurements. Design project. Weekly laboratory. Prerequisites: ME 10, Mat 33, Mech 12.

ME 252. Mechanical Elements (3) fall, spring
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies. Prerequisites: Mech 12, ME 10 and Mech 102.

For Advanced Undergraduates and Graduate Students

ME 231. Fluid Mechanics (3) fall, spring
Kinematics of fluid flow and similarity concepts. Equations of incompressible fluid flow with inviscid and viscous applications. Turbulence. One-dimensional compressible flow, shock waves. Boundary layers, separation, wakes and drag. Prerequisite: Math 205.

ME 242. Mechanical Vibrations (3) fall, spring
Physical modeling of vibrating systems. Linearization. Free and forced single and multiple degree of freedom systems. Simple continuous systems. Engineering applications. Prerequisites: Mech 12, Mech 102 or 103, Math 205.

ME 310. Directed Study (1-3) fall, spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Project progress is reported in the form of several planning and project reports. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: consent of the department chairperson.

ME 312. Synthesis of Mechanisms (3) fall
Geometry and constrained plane motion with application to linkage design. Type of number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math 205, Mech 102. Terry

ME 321. Introduction to Heat Transfer (3) fall, spring
Analytical and numerical solutions to steady and transient one- and two-dimensional conduction problems. Forced and natural convection in internal and external flows. Thermal radiation. Thermal design of engineering processes and systems. Prerequisite: ME 104, ME 231. Walker, Neti, Levy

ME 322. Gas Dynamics (3) spring
Flow equations for compressible fluids; thermodynamic properties of gases. Normal shock waves. Steady one-dimensional flows with heat addition and friction. Oblique shock waves. Expansion waves. Nozzle flows. Shock tubes; performance calculations and design. Supersonic wind tunnels; diffuser design. Prerequisites: ME 231, ME 104, Math 205. Blythe, Owczarek

ME 323. Reciprocating and Centrifugal Engines (3) fall
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air

breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered. Prerequisite: ME 105.

ME 331. Advanced Fluid Mechanics (3) fall
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Flow of non-Newtonian fluids. Hydrodynamic lubrication. Measurement techniques. Prerequisite: ME 231 or equivalent. Owczarek, Rockwell, C. Smith

ME 340. Advanced Mechanical Design (3) fall
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints. Prerequisite: Math 231. Benner

ME 341. Mechanical Systems (3) spring
Advanced topics in mechanical systems design. Kinematics and dynamics of planar machinery. Shock and vibration control in machine elements. Balancing of rotating and reciprocating machines. Design projects using commercial computer-aided-engineering software for the design and evaluation of typical machine systems. Prerequisite: ME 252. Lucas

ME 342. Dynamics of Engineering Systems (3) spring
Steady-state and dynamic analysis of mechanical, electro-mechanical, fluid and thermal engineering systems with emphasis on the modeling process. Use of computer tools for modeling, design and simulation. Design projects. Prerequisite: ME 242. Brown

ME 343. Control Systems (3) fall
Linear analyses of mechanical, hydraulic and electrical feedback control systems by root locus and frequency response techniques. A design project provides experience with practical issues and tradeoffs. Prerequisite: ME 242. Johnson

ME 345. Fluid Power (3) fall
Design, modeling and static and dynamic analyses of fluid power pumps, motors, valves, lines and systems, with emphasis on developing a fundamental understanding of industrial and mobile hydraulics and hydraulic servosystems. Laboratory demonstrations and experiments; design projects. Prerequisites: ME 231 and, previously or concurrently, ME 242. Brown

ME 348. Computer-Aided Design (3) spring
Impact of computer-aided engineering tools on mechanical design and analysis. Part geometry modeling and assembly modeling using solid representations. Analysis for mass properties, interference, kinematics, displacements, stresses and system dynamics by using state-of-the-art commercially available computer-aided-engineering software. Integrated design projects. Two 1-hour lectures and 2-hour lab per week. Prerequisites: ME 10, ME 252, ME 242. Lucas, Ochs, Ozsoy.

ME 350. Special Topics (1-4)
A study of some field of mechanical engineering not covered elsewhere. Prerequisite: consent of the department chairperson.

ME 360. Nuclear Reactor Engineering (3) spring
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation,

reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Prerequisite: Senior standing in engineering or Physical Science. Net

ME 387. (ChE 387, ECE 387) Digital Control (3) spring
Sampled-data systems; z -transforms; pulse transfer functions; stability in the z -plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (2 lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 343 or consent of instructor. Layben

ME 389. (ECE 389) Control Systems Laboratory (2)
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisites: Either ChE 386, ME 343, or ECE 212.

Graduate Programs in Mechanical Engineering

The department offers programs of study leading to the degrees of master of science, master of engineering, and doctor of philosophy in Mechanical Engineering.

A student whose background is different from that required in the undergraduate mechanical engineering curriculum or who has a particular deficiency may be required to present a larger number of credits than the minimum indicated for graduation.

Subject to approval, courses from other engineering curricula, such as mechanics, materials science and engineering, and chemical, electrical, and industrial engineering, may be included in the major.

A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations.

Master of Science

The M.S. Degree program provides students with opportunities for more in-depth studies of mechanical engineering and a broader background in related subject areas. Breadth is ensured through a series of required (three of four) core courses and depth through selected electives in the student's area of interest.

A *thesis option* and a *non-thesis option* are offered. The thesis option is for students who desire to enhance their capabilities in mechanical engineering and to gain research project experience in a team effort with a faculty member; it requires six credit hours of thesis in a specialized area. The non-thesis option is for students desiring to advance their expertise in mechanical engineering through a concentrated course of study, and requires two three-credit-hour graduate courses in lieu of the thesis.

Doctor of Philosophy

Candidacy for the Ph.D. degree follows passing of the qualifying examinations, which also emphasize broad grasp of fundamentals, and forming of a special Ph.D. Committee. In most cases, largely through the dissertation, the candidate emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Research opportunities involve strong programs in both analysis and experimentation.

The department has a wide range of state-of-the-art computational and experimental systems. Computers include Stardent and Kubota Titan mini-supercomputers, eleven IBM RS-6000 workstations, fifteen Hewlett-Packard workstations, and eight Silicon Graphics workstations. In addition, the University supports networks of hundreds of PC's and other microcomputers and workstations. Experimental facilities include eleven pulsed and

continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems, a number of unique facilities for observing and controlling flow past surfaces and through machines. There are well-equipped laboratories for multi-disciplinary studies of failure of materials in extreme environments, in conjunction with a number of surface analysis and electron microscopy facilities on campus. Extensively equipped, interdepartmental robotics, controls, and manufacturing laboratories are also available.

Some of the recent research activities are listed below:

Thermofluids. Structure of turbulent boundary layers, wakes and jets; vortex-solid boundary interactions; boundary layers in compressible flow, including hypersonic regimes; vortex breakdown in internal machinery and in flow past wings; drag reduction in turbulent flows; flow-induced noise and vibration; flutter of blades in axial-flow turbomachinery and of tails and fins on aircraft; unsteady aerodynamic flows past three-dimensional wings and bodies; flow structure and heat transfer at end-wall junctions in rotating machinery and on surfaces of aircraft; flows in micro-hydro-electromechanical systems; convective heat transfer in systems of electronic components; flows through complex components of power generation systems; transport of coal particles; flow and heat transfer in fluidized beds; cycle analysis applied to coal gasifiers; control optimization of heat pumps; laser-Doppler and particle velocimetry; liquid crystal sensors for heat transfer; Raman spectral techniques applied to two-phase flow; laser diagnostics and image processing of complex flow and heat transfer systems.

Systems Dynamics and Controls. Modeling and advanced simulation of dynamic systems including vehicles, chemical processes, aeroelastic structures, and heat-pump systems. Methods of experimental identification and analysis of distributed-parameter systems including microelectromechanical components, space deployment platforms; energy methods and bond graphs in modeling; stochastic optimal control techniques applied to stable platform for overland vehicles; conceptualization and hardware development of innovative components and systems for fluid power control; application of robotics to manufacturing; computer-controlled theater lighting design.

Except for core courses, graduate courses are generally offered every third semester.

ME 411. Boundary-Layer Theory (3) fall

The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two-and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows. Walker

ME 413. Numerical Methods in Mechanical Engineering (3)

Zeros of functions, difference tables, interpolation, integration, differentiation. Divided differences, numerical solution of ordinary differential equations of the boundary and initial value type. Eigen problems. Curve fitting, matrix manipulation and solution of linear algebraic equations. Partial differential equations of the hyperbolic, elliptic and parabolic type. Application to problems in mechanical engineering. Walker

ME 415. Flow-Induced Vibrations (3)

Excitation of streamlined- and bluff-bodies by self-flutter, vortex, turbulence, and gust-excitation mechanisms. Analogous excitation of fluid (compressible- and free-surface) systems having rigid boundaries. Extensive case studies. Rockwell

ME 420. Advanced Thermodynamics (3) spring

Critical review of thermodynamics systems. Criteria for

equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena. Macpherson

ME 423. Heat and Mass Transfer

This course is a first graduate course in the basic concepts of heat and mass transfer, providing a broad coverage of key areas in diffusion, conduction, convection, heat and mass transfer, and radiation. Topics covered include: the conservation equations, steady and transient diffusion and conduction, periodic diffusion, melting and solidification problems, numerical methods, turbulent convection, transpiration and film cooling, free convection; heat transfer with phase change, heat exchanges, radiation, mixed mode heat and mass transfer.

ME 421. Topics in Thermodynamics (3)

Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation. Staff

ME 424. Turbulent Flow (3) fall

Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Rockwell

ME 426. Radiative and Conductive Heat Transfer (3) spring

Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: ME 321 or ChE 421. Staff

ME 427. (ChE 427) Multiphase Heat Transfer (3)

Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME 321 or ChE 421. Staff

ME 428. Boundary Layers and Convective Heat Transfer (3) spring

Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory. Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy, Owczarek, Rockwell

ME 430. Advanced Fluid Mechanics

This course is a first graduate course in incompressible fluid mechanics, providing a broad coverage of key areas of viscous and inviscid fluid mechanics. Topics covered include: Flow kinematics, differential equations of motion, viscous and inviscid solutions, vorticity dynamics and circulation, vorticity equation, circulation theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences.

ME 431. Advanced Gas Dynamics (3)

Method of characteristics. Unsteady continuous flow. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids. Prerequisite: ME 322. Owczarek, Rockwell

ME 432. Topics in Gas Dynamics (3)

The equilibrium thermodynamic properties of a dissociating mixture of gases. Equilibrium flow of dissociating gases. Vibrational and chemical nonequilibrium. Criteria for thermodynamic equilibrium of gas flow. Chemical kinetics of gaseous reactions. Equations of flow of a reacting gas mixture. Nonequilibrium flows. Application to design of ram-jets and rocket nozzles and of reentry vehicles. Prerequisite: ME 320 and ME 322. Staff

ME 433. (ChE 433, ECE 433) State Space Control (3)

State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor. Johnson, Georgakis

ME 434. (ChE 434, ECE 434) Multivariable Process Control (3)

A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Georgakis

ME 436. (ChE 436, ECE 436) Systems Identification (3)

The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-embedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

ME 437. (ChE 437, ECE 437) Stochastic Control (3)

Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Staff

ME 439. Fluid Mechanics of Turbo-machinery (3)

The Euler equation. One-dimensional analysis of turbomachinery. Performance characteristics. Limitations on performance imposed by real fluid effects. Cascade flow. Two- and three-dimensional flow. Surge and stall. Owczarek

ME 442. Analytical Methods in Engineering I (3) fall

Analytical methods of solution for discrete and continuous engineering systems. Theoretical, numerical and approximate methods of solution applied to equilibrium, characteristic value and propagation types of engineering problems. Lucas, Walker, Erdogan, Sawyers, Varley

ME 443. Analytical Methods in Engineering II (3) spring

Continuation of ME 442.

ME 444. Experimental Stress Analysis in Design (3)

Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity, stress separation techniques, birefringent coating Moire methods, caustics.

Use of image analysis in data acquisition and interpretation. Selected laboratory experiments. Voloshin

ME 446. Mechanical Reliability (3)

Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: Math 231 or Math 309. Benner

ME 450. Special Topics (3)

An intensive study of some field of mechanical engineering not covered in more general courses.

ME 451. Seminar (1-3)

Critical discussion of recent advances in mechanical engineering.

ME 458. Modeling of Dynamic Systems (3)

Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Analog, digital and hybrid simulation. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Prerequisite: ME 342 or ME 343 or ECE 212. Brown, Johnson

ME 460. Engineering Project (1-6)

Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chairperson.

ME 464. Computer-Aided Geometric Modeling (3)

Representation schemes for geometric modeling, computational geometry for curve and surface design, finite-element meshing and NC tool path generation, interfacing different CAD/CAM databases, interactive computer graphics programming. Prerequisite: ME 348 or consent of instructor. Özsoy

ME 466. Fundamentals of Acoustics (3)

Vibration-induced acoustic radiation, wave equation in planar, cylindrical and spherical coordinates. Sound in tubes, pipes, wave guides, acoustic enclosures. Impedance and source-media-receiver transmission concepts. Noise and its measurements. Ochs

ME 490. Thesis

ME 499. Dissertation

B.S. in Engineering Mechanics

The curriculum in Engineering Mechanics is designed to prepare students for careers in engineering research and development and is especially appropriate for students wishing to specialize in the analysis of engineering systems. In many industries and governmental laboratories there is a certain demand for men and women with broad training in the fundamentals of engineering in which engineering mechanics and applied mathematics play an important part.

The first two years of the curriculum is the same as that in Mechanical Engineering. One of the advantages of the curriculum is the flexibility it offers through 18 credits of technical and 6 credits of personal electives in the junior and senior years. Beyond the sophomore year there are required courses in dynamics, solid mechanics, fluid mechanics, heat transfer, principles of electrical engineering, mathematics, vibrations, and senior laboratories or projects. It is recommended that the electives be chosen either to concentrate on areas such as applied mathematics and computational mechanics, solid mechanics, engineering materials, and fluid mechanics or to obtain further depth in all areas. Each student must select a minimum of 12 credits

from the courses listed under options and six additional credits of approved technical electives from this list or from other courses offered in the departments of mathematics, physics or chemistry, or in the college of engineering and applied science. The academic advisor for the Engineering Mechanics program will provide guidance in formulating the student's goals and choosing the electives.

In addition to the required and elective courses in mathematics, sciences and engineering, the B.S. degree program in Engineering Mechanics includes 25 credits of Humanities and Social Sciences (page 35). The total graduation requirement is 131 credits.

Undergraduate Curriculum in Engineering Mechanics

freshman and sophomore years: same as ME curriculum

junior year, first semester (17 credit hours)

Mech 102	Dynamics (3)
ME 231	Fluid Mechanics (3)
ME 121	Mechanical Engineering Lab II (1)
ECE 81	Principles of Electrical Engineering (4)
ME 240	Manufacturing (3)
HSS	Humanities/Social Sciences (3)

junior year, second semester (16 credit hours)

ECE 162	Electrical Laboratory (1)
ME 242	Mechanical Vibrations (3)
Math 208	Complex Variables (3)
Math 230	Numerical Methods (3)
HSS	Humanities/Social Sciences (3)
	Engineering Mechanics elective (3)

senior year, first semester (17 credit hours)

ME 321	Introduction to Heat Transfer (3)
	(or equivalent)
ME 207	Mechanical Engineering Laboratories III (2) or
ME 210	Laboratory Projects (2)
	free elective (3)
HSS	Humanities/Social Sciences (3)
	Engineering Mechanics electives (6)

senior year, second semester (17 credit hours)

ME 208	Mechanical Engineering Laboratories IV (2) or
ME 110	Laboratory Projects (2)
HSS	Humanities/Social Sciences (3)
	free elective (3)
	Engineering Mechanics electives (9)

Total credits for graduation: 131

Typical recommended options

Applied Mathematics and Computational Mechanics

Math 322	Methods of Applied Analysis I (3)
Math 323	Methods of Applied Analysis II (3)
Mech 305	Advanced Mechanics of Materials (3)
Mech 312	Finite Element Analysis (3)
Math 309	Theory of Probability (3)

Solid Mechanics

Math 322	Methods of Applied Analysis I (3)
Mech 305	Advanced Mechanics of Materials (3)
Mech 312	Finite Element Analysis (3)
Mech 313	Fracture Mechanics (3)
Mech 307	Mechanics of Continua (3)

Engineering Materials

Phys 31	Introduction to Quantum Mechanics (3)
Mat 218	Mechanical Behavior of Materials (3)
Phys 363	Physics of Solids (3)

Mech 305 Advanced Mechanics of Materials (3)

Fluid Mechanics

Math 322 Methods of Applied Analysis I (3)
ME 331 Advanced Fluid Mechanics (3)
Mech 326 Aerodynamics (3)

Engineering Materials

Phys 31 Introduction to Quantum Mechanics (3)
Mat 218 Mechanical Behavior of Materials (3)
Phys 363 Physics of Solids (3)
Mech 305 Advanced Mechanics of Materials (3)

Fluid Mechanics

Math 322 Methods of Applied Analysis I (3)
ME 331 Advanced Fluid Mechanics (3)
Mech 326 Aerodynamics (3)

Undergraduate Courses in Engineering Mechanics

Mech 2. Elementary Engineering Mechanics (3)

Static equilibrium of particles and rigid bodies; analysis of simple structures; internal forces, stress, strain, and Hooke's Law; statically indeterminate torsion of circular shafts; pure bending of beams. Prerequisites: Math 22 and Phys 11. (Math 22 may be taken concurrently)

Mech 12. Strength of Materials (3)

Mohr's circle for stress; plastic deformation, failure criteria; transverse shearing stresses in beams; deflection analysis of beams; strain energy methods; column buckling; analysis of thick-walled cylinders. Prerequisites: Mech 2, Math 23 (previously or concurrently).

Mech 102. Dynamics (3) fall, spring

Particle dynamics, work-energy, impulse-momentum, impact, systems of particles; Kinematics of rigid bodies, Kinetics of rigid bodies in plane motion, energy, momentum, eccentric impact. Prerequisites: Mech 2 and Math 23.

Mech 103. Principles of Mechanics (4)

Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: Math 23 and Phys 11.

For Advanced Undergraduates and Graduate Students

Mech 302. Advanced Dynamics (3) spring

Fundamental dynamic theorems and their application to the study of the motion of particles and rigid bodies, with particular emphasis on three-dimensional motion. Use of generalized coordinates; Lagrange's equations and their applications. Prerequisites: Mech 102 or 103; Math 205. Sarubbi, Johnson

Mech 305. Advanced Mechanics of Materials (3) fall

Strength, stiffness, and stability of objects used in mechanical engineering. Stresses and deformations for problems such as thick-walled cylinders, spinning disks, thermal stresses, contact stresses, curved beams, beam-columns, torsion, pressure vessels, energy methods, and limit analysis. Projects relate analysis to engineering design. Prerequisites: Mech 12, Math 205

Mech 307. Mechanics of Continua (3) spring

Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to two-dimensional problems in finite elasticity, plasticity, and viscous flows. Prerequisite: Mech 305. Varley

Mech 312. Finite Element Analysis (3) spring

Basic concepts of analyzing general media (solids, fluids, heat transfer, etc.) with complicated boundaries. Emphasis on design of mechanical elements and structures. Element stiffness matrices by minimum potential energy. Isoparametric elements. Students use short, prewritten Fortran subroutines to assemble their own self-contained finite element codes. Applications to design of mechanical elements. Prerequisite: Mech 12. Kalnins

Mech 313. Fracture Mechanics (3) spring

Fracture mechanics as a foundation for design against or facilitation of fracture. Fracture behavior of solids; fracture criteria; stress analysis of cracks; subcritical crack growth, including chemical and thermal effects; fracture design and control, and life prediction methodologies. Prerequisites: Mech 12, Math 205, or approval of department. Sih, Wei

Mech 326. Aerodynamics (3) spring

Application of fluid dynamics to flows past lifting surfaces. Normal force calculations in inviscid flows. Use of conformal mappings in two-dimensional airfoil theory. Kutta condition at a trailing edge; physical basis. Viscous boundary layers. Thin airfoil theory. Section design; pressure profiles and separation. Lifting line theory. Compressible subsonic flows; Prandtl-Glauert Rule. Airfoil performance at supersonic speeds. Prerequisites: ME 231 and Math 205. Blythe

Mech 350. Special Topics (3)

A study of some field of engineering mechanics not covered elsewhere. Prerequisite: consent of the department chairperson.

Graduate Program in Engineering Mechanics

The department offers programs of study leading to the degrees of master of science, and doctor of philosophy. These graduate degrees are given in *Applied Mechanics*.

The program is open in general to students who have graduated from a curriculum in engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution. A student whose background is different from that required in these undergraduate curricula or who has a particular deficiency may be required to present a larger number of credits than the minimum required for graduation.

A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations.

Master of Science

The M.S. degree program provides students with opportunities for more in-depth studies of engineering mechanics and a broader background in related subject areas. Breadth is ensured through a series of required (three of four) core courses, and depth, through selected electives in the student's area of interest.

A *thesis option* and a *non-thesis option* are offered. The thesis option is for students who desire to enhance their capabilities in engineering mechanics and to gain research project experience in a team effort with a faculty member; it requires six credit hours of thesis in a specialized area. The non-thesis option is for students desiring to advance their expertise in engineering mechanics through a concentrated course of study, and requires two three-credit-hour graduate courses in lieu of the thesis.

A candidate for the M.S. in applied mechanics is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math 205, 208 and 322, and Mech 302 and 305, or their equivalents, are considered prerequisites for graduate work in applied mechanics.

Doctor of Philosophy

Candidacy for the Ph.D. degree follows passing of the qualifying examinations, which also emphasize broad grasp of fundamentals, and forming of a special Ph.D. committee. In most cases, largely through the dissertation, the candidate

emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Research opportunities involve strong programs in both analysis and experimentation.

The department has a wide range of state-of-the-art computational and experimental systems. Computers include Stardent and Kubota Titan mini-supercomputers, eleven IBM RS-6000 workstations, fifteen Hewlett-Packard workstations, and eight Silicon Graphics workstations. In addition, the University supports networks of hundreds of PC's and other microcomputers and workstations. Experimental facilities include eleven pulsed and continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems, and a number of unique facilities for observing and controlling flow past surfaces and through machines. There are well equipped laboratories for multi-disciplinary studies of crack growth in deleterious environments and at elevated temperatures, in conjunction with a number of surface analysis and electron microscopy facilities on campus. Extensively equipped, interdepartmental robotics, controls, and manufacturing laboratories are also available.

Some of the recent research activities are listed below.

Continuum and solid mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories. Mechanics of viscoelastic solids and fluids, plasticity theory. Generalized continuum mechanics. Thermomechanical and electromechanical interactions. Analyses and modeling of manufacturing processes. Free vibration and dynamic response of elastic shells, elastic-plastic deformation of shells upon cyclic thermal loading, and applications of shell analysis to nuclear power plant components and biological systems. Stress birefringence. Wave propagation. Finite amplitude wave propagation.

Fracture mechanics. Stress analysis of materials containing defects, including viscoelastic, non-homogeneous, and anisotropic materials. Analysis and modeling of crack growth under static, periodic, and random loadings and environmental effects. Optimizations of fracture control. Crack propagation theories for nonlinear materials. Influence of cracks on the strength of structural members and of interfaces. Hydraulic fracture. Applications to reliability and durability of composites, structural and microelectronic components, and to processes for resource recovery.

Stochastic processes. Modeling of random behavior in mechanical systems. Static and time-dependent stochastic fracture mechanics, with particular applications to assessments of reliability and service life prediction.

Theoretical fluid mechanics. Vortex boundary layer interaction, modeling of turbulent boundary layers; geophysical flows such as frontal systems and mountain flows; statistical mechanics of plasmas, liquids and shock waves; finite amplitude waves in stratified gases and liquids; shock wave propagation; non-Newtonian flows in flexible tubes with application to hemorheology; magneto-fluid mechanics; wing theory; thermally driven flows.

Special departmental facilities of interest to the graduate student include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic bench, laser, and corrosion fatigue test facilities.

Except for the core courses graduate courses are generally offered every third semester.

Mech 402. Advanced Analytical Mechanics (3) fall

Fundamental dynamical theorems and their applications to advanced problems; generalized coordinate; Lagrange's equations; fixed and moving constraints; nonholonomic systems; Hamilton's principle; Hamilton's canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech 302 or consent of the department chairperson. Johnson, Sarubbi

Mech 405. Response of Systems to Random Loads (3) fall
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability of the

random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of the department chairperson. Harlow, Sarubbi

Mech 406. Advanced Dynamics and Vibrations (3) fall

Kinematical and mathematical preliminaries, basic notions of variational calculus; Hamilton's principle. Lagrange equations, discrete systems; dynamics of continuous systems. Sturm-Liouville theory, eigenvalue problems; transient and frequency response. There will be frequent examples of the application of these techniques to the analysis of shafts, beams, membranes, and plates. Prerequisites: ME 242 and Mech 302. Erdogan, S. Johnson

Mech 407. Wave Propagation in Solids (3) fall

Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Erdogan, Delph, Varley

Mech 408. Introduction to Elasticity

This course is a first graduate course in solid mechanics. It addresses: kinematics and statics of deformable elastic solids; compatibility, equilibrium and constitutive equations; problems in plane elasticity and torsion; energy principles, approximate methods and applications.

Mech 409. Theory of Elasticity I (3) fall

Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-plane, torsion, bending and plane problems. Approximate and numerical methods of solution. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of material. Erdogan, Hartranft, Sih

Mech 410. Theory of Elasticity II (3) spring

Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech 409, Math 208, or consent of the department chairperson. Erdogan, Sih

Mech 411. (Phys 471) Continuum Mechanics (3)

An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. G. Smith

Mech 412. Theory of Plasticity (3)

Time-independent mechanical behavior in simple tension, compression and torsion. Time-independent stress-strain relations for materials under combined stress. Application to problems with axisymmetric stress distributions. Loading, unloading, residual stresses, shakedown. Limit theorems of perfectly plastic bodies; applications. The slip line field for plane strain; examples. Plastic analysis of structures; frames, plates, shells. Finite element approach to problems. Time-dependent mechanical behavior of materials, creep. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins, Updike

Mech 413. Fracture Mechanics (3)

Introduction to fracture mechanics criteria for bodies containing cracks and notches; microscopic and macroscopic analytical modeling; fracture toughness concept; test specimens; stress intensity factor evaluation of crack systems; prediction of crack trajectory and direction of initiation; dynamic loading and crack propagation; fatigue crack growth and environmental effects; brittle-ductile transition phenomenon in metals; visco-elastic behavior of polymers. Prerequisites: Mech 203, Math 208, or consent of the department chairperson. Erdogan, Sih, Wei

Mech 414. Viscoelasticity and Creep (3)

Mechanical models for linear viscoelastic materials, representations by differential operators and hereditary integrals, creep and relaxation functions, correspondence principle, quasi-static analysis, wave propagation, nonlinear material behavior, uniaxial creep laws, multiaxial generalizations, creep damage and failure. Prerequisite: Mech 409. Delph

Mech 415. (CE 468) Stability of Elastic Structures (3)

Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

Mech 416. (CE 464) Analysis of Plates and Shells (3) fall
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of inplane forces, large deflections, buckling of plates. Geometry and governing equations of shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, non-symmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math; Mech 305, or equivalent course in advanced mechanics of materials. Kalnins, Updike

Mech 417. Mixed Boundary Value Problems in Mechanics (3)

General description of mixed boundary value problems in potential theory and solid mechanics. Solutions by dual series, dual integral equations and singular integral equations. Approximate and numerical methods. Erdogan

Mech 418. Finite Element Methods (3) fall

Finite element approximations to the solutions of differential equations of engineering interest are developed from variational principles or by Galerkin's method. Linear and nonlinear example from heat transfer, solid mechanics, and fluid mechanics are used to illustrate applications of the method. The course emphasizes the development of computer programs to carry out the required calculations. Prerequisite: knowledge of FORTRAN. Delph

Mech 419. (ChE 419) Asymptotic Methods in the Engineering Sciences (3)

Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansion. W.K.B. Theory. Far field theories. Blythe

Mech 421. Fluid Mechanics (3)

Kinematics of fluid flow. Lagrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulation. Irrotational flow. Bernoulli theorems. Vortex motion, velocity motion, velocity potential, stream function. Potential flow in two and three dimensions. Compressible flow; sound waves, simple waves; gas dynamic discontinuities. Salathe, Blythe

Mech 422. Fluid Mechanics (3)

Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from Magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: Mech 421. Salathe, Blythe

Mech 424. Unsteady Fluid Flows (3)

Gas dynamics, finite amplitude disturbances in perfect and

real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface; basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics; pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

Mech 425. Analytical Methods in Dynamics and Vibrations

This course is a first graduate course in dynamics and vibrations. It treats three-dimensional rigid body motion by vector methods and multidegree of freedom systems by variational principles. Discrete modal analysis and continuous modal analysis of one-dimensional systems plus finite-element formulation of numerical problems constitutes about one-third of the course. There is a brief treatment of advanced impact. Use of symbolic computer codes is encouraged.

Mech 490. Thesis**Mech 499. Dissertation****Mech 437. (Mat 437) Dislocations and Strengths in Crystals (3)**

Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening plastic flow, creep, fatigue and fracture are discussed. Prerequisites: Math 205 or 221, or Met 320; Met 317, or consent of the department chairperson. Chou, Wei

Mech 450. Special Problems (3)

An intensive study of some field of applied mechanics not covered in more general courses.

Mech 454. Mechanics and Design of Composites (3)

Mechanics of anisotropic materials. Manufacturing and measurements of mechanical properties. Stress analysis for design of composite structures. Hygrothermal effects and residual stresses. Laminate design, micromechanics of lamina. Bolted and bonded joints. Impact and damage in composites. Lectures and laboratory. Prerequisite: Elementary course in elasticity (Mech 305 or equivalent). Voloshin

Engineering Mathematics Courses**EMA 425. Variational Methods in Science and Engineering (3)**

Variational problems with one independent variable; Euler-Lagrange equations; methods of solution; space and time dependent fields; null Lagrangians and inhomogeneous Dirichlet data; problems with constraints; symmetries and conservation laws; variational approximation methods, Rayleigh-Ritz, Galerkin, finite element, and collocation. Problems and examples will be drawn from the mechanics of solids, fluids, and related fields. Prerequisite: consent of chairman. Edelen

EMA 450. Special Topics (3)

An intensive study of some field of engineering mathematics not covered in other courses.

EMA 490. Thesis**EMA 499. Dissertation****Military Science**

Professor. MAJ Stuart S. Taylor, M.A. (University of Oklahoma), *chairperson*.

Assistant professors. CPT Joseph Bonavita, B.A. (University

of Tennessee); CPT Kevin F. Elliott, B.S. (Temple); CPT Jonathan Scott, B.A. (University of Alabama); CPT David E. Swift, B.A. (University of Southeastern Massachusetts).
Instructors. MSG Kenneth C. Ullom, SFC Orlando Welsh.

The Department of Military Science, established in 1919, conducts the Army Reserve Officer Training Corps (ROTC) program at Lehigh University. This is one of the oldest ROTC programs in the nation. The Army ROTC program provides a means for students to qualify for a commission as an officer in the Active Army, Army Reserve, or Army National Guard.

The objectives of the military science program are to develop leadership and management ability in each student; to provide a basic understanding of the Army's history, philosophy, organization, responsibilities, and role in American society; and to develop fundamental professional knowledge and skills associated with officership. These objectives are achieved through classroom instruction, leadership laboratories, field trips, role playing, leadership simulations, and individual assessment and counseling.

Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year basic course and a two-year advanced course. The two-year program consists of the two-year advanced course offered to students with previous military experience, and those who have successfully completed a six-week ROTC basic summer camp. Basic course students incur no obligation for service in the Army as a result of taking these courses.

Basic Course. The basic course, normally taken in the freshman and sophomore years, provides training and instruction in leadership and basic military subjects, such as the Army's role and organizational structure, history and philosophy of the Army, basic tactics, land navigation, first aid, group dynamics, and leadership traits and characteristics. Basic course students incur no military obligation.

Advanced Course. The advanced course is normally taken in the junior and senior years. The instruction includes management, military skills, advanced leadership, logistics, administration, military law, ethics, and professionalism, and includes attendance at ROTC Advanced Camp. Students receive \$100 per month subsistence pay during the junior and senior years.

To enroll in the advanced course, an applicant: completes either the basic course or the six-week basic summer camp; or has received basic course credit for previous military experience; and is accepted for enrollment by the university and the department of military science.

Uniforms and Equipment. All uniforms and equipment needed by the student for military science courses are supplied by the department. Students are charged only for those items not returned when they leave the program.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate level and year, provided they have received the necessary credits, the recommendation of their former professor of military science (if applicable), and the approval of the university.

Obligation after graduation. Upon graduation a student will receive a commission as a Second Lieutenant in either the Active Army or the Reserve Forces. The service obligation is for 8 years to include an initial period of Active Duty of up to 4 years depending upon Army requirements. The remainder of the service obligation will be served in the Reserve Components. The Army may not require the student to serve on Active Duty except for an initial period of Active Duty training of 3 to 6 months. The remainder of the 8 year service obligation will then be served in either the Army Reserve or Army National Guard.

Graduate studies. ROTC graduates may request to delay their active service to pursue a full-time course of instruction leading to an advanced degree. Delay does not lengthen the active service obligation unless the degree is obtained at government expense.

Course credit. Students in the College of Arts and Science and the College of Business and Economics may substitute military science advanced credits for six hours of electives. In the College of Engineering and Applied Science, six credits

of advanced ROTC work are permissible within the normal program of each student, irrespective of curriculum. For curricula that include more than six hours of personal electives in the junior and senior years, inclusion of the more than six hours of ROTC credit with normal programs can be effected only with the approval of academic advisers. All military science credits, including those in the basic course, apply toward the student's over-all cumulative grade point average.

Career Opportunities

Individuals are commissioned as officers in the United States Army after completion of the ROTC program and the advanced camp and completion of their bachelor's degree requirements. They then qualify for active duty in the Army in branches (specialties) such as the Corps of Engineers, Infantry, Armor, Aviation, Field Artillery, Air Defense Artillery, Signal Corps, Military Intelligence, Chemical Corps, Ordnance Corps, Finance, Transportation, Quartermaster, Medical Service Corps, or Nursing. Officers work as leader/managers, specialists, or combinations of the two depending on the assignment.

There are opportunities for advanced military and civilian schooling beginning with nearly three months of training in the branch specialty. A person may also receive an additional specialty in such areas as systems analysis, research and development, foreign area specialization, comptroller, or public affairs, depending on individual expertise. Students may be selected for reserve forces duty. Reserve forces duty provides the student with the opportunity to maintain the options of a military or civilian career upon completion of the program. Those individuals who receive reserve forces duty become officers in the Army Reserve or Army National Guard in their hometown area and essentially have a part-time military career. An officer can earn retirement through both programs after twenty years of service.

Physical facilities. Army ROTC uses areas on and adjacent to the university campus to conduct field training. These locations are excellent for most outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation, located east of Harrisburg, Pa., is used for field training exercises and weapons familiarization during the two annual weekend field exercises. Trips to active Army installations such as Aberdeen Proving Ground, Maryland, and Fort Dix, New Jersey are also available. Other locations used for cadet adventure training are: Delaware and Lehigh rivers (rafting); and the university's Saucon Valley athletic complex.

Programs and Opportunities

ROTC Scholarship Program. This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Each scholarship provides most tuition, a textbook and supplies allowance, and laboratory fees, in addition to pay of \$100 per month for the period the scholarship is in effect. Three-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing their freshman year of college. This program is also open to all qualified students who are not currently enrolled in Army ROTC.

Four-year scholarships are open to all students entering ROTC as freshmen. Recipients of an ROTC scholarship are required to complete at least one semester of Indo-European or Asian language prior to commissioning. Applications for scholarship must be made to Headquarters, U.S. Army Cadet Command, Fort Monroe, VA by August 15th prior to the senior year for early selection, but no later than December 1st for normal application. Application booklets are available from most high school guidance offices, or may be obtained from the Military Science Department of the University.

Two-Year Program. Students who want to enroll in ROTC after their sophomore year may apply. Applicants must successfully complete a six-week basic ROTC summer camp and have two years of undergraduate or graduate studies

remaining. The student is paid for the six-week encampment and receives transportation costs to and from the camp. Individuals begin the advanced course after the basic camp.

Distinguished Military Graduate (DMG) program. This is a competitive program that permits outstanding ROTC students to apply for a Regular Army commission immediately upon graduation. At the end of the junior year and upon completion of the advanced summer camp, approximately one third of each senior ROTC class may be designated as Distinguished Military Students (DMS). A student who maintains the same high standards throughout the senior year may qualify for designation as a Distinguished Military Graduate (DMG) and may be offered a Regular Army commission upon graduation.

Off-campus U.S. Army Training Schools. Cadets may be selected to attend the following U.S. Army Schools: Airborne School (Fort Benning, Georgia), Air Assault school (Fort Campbell, Kentucky), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army.

Minor in Military Science. A minor in Military Science is available in the College of Arts and Science. A minor in Military Science consists of 37 credit hours beyond the basic Military Science course and is designed to provide the student with an academic foundation necessary to support continued intellectual growth and stimulate future inquiry in the realm of civil military affairs and Military Science. Credit hours required are distributed as follows:

Military Science (12)

MS 101	Advanced Military Skills (3)
MS 102	Advanced Leadership (3)
MS 113	Military Command and Staff (3)
MS 114	Officer Responsibilities, Ethics and Military Professionalism (3)
HS 118	Special Military Topics (1)

History (3)

Hist 310	American Military History (3)
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International Relations (3) (Select one of the following)

IR 1	World Politics: Evolution of the International System (3)
IR 2	World Politics: Concepts and Principles (3)
IR 51	American Foreign Policy Since 1945 (3)
IR 312	World Affairs Since 1945 (3)
IR 371	Reading in International Relations (3)

Written Communications (3) (Select one course from one of the following categories)

- Creative Writing
- Scientific Writing
- Writing for Mass Communications

Human Behavior (3) (Select one course in one of the following categories)

- General Psychology
- Sociology
- Anthropology
- Ethics

Indo-European or Asian Language (6)

Math Reasoning Course

Math 5	Introduction to Mathematical Thought (3) or More Advanced Course
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Computer Literacy Course

CSC 11	Introduction to Structure Programming (3) or More Advanced Course
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Commissioning Requirements

Individuals must complete either the two- or four-year programs, attend the advanced camp, and receive a college degree, have a CUM GPA of 2.0, and complete all professional military education requirements to become commissioned officers in the United States Army.

Course Descriptions

Leadership Laboratory is conducted for all students on Monday afternoons. The Leadership Laboratory provides students the opportunity to demonstrate an understanding of the leadership process and develop fundamental military skills.

Instruction at several levels on a variety of subjects with military application provides the context within which students are furnished opportunities to both teach and lead in a group setting. Responsibility is expanded as the student progresses through the program. In the senior year, the students assume the responsibility for the planning, preparation and conduct of the laboratory. Leadership Laboratory is mandatory for all students enrolled in Military Science courses.

15. Introduction to Military Science (1) fall

The American Army as an institution, its roots, history, customs and traditions and philosophy of leadership. Emphasis on development and role of a professional officer corps. Includes leadership laboratory and one field trip.

16. Leadership Assessment and Group Dynamics (1) spring

Role of individual and leader within the group, leadership skills and characteristics. Emphasis on problem solving and application. Includes laboratory and FTX.

23. Topographic Analysis and Land Navigation (2) fall

Maps as tools in basic terrain analysis and as navigational aids. Emphasis on application and field exercises at individual and small group levels. Includes laboratory and FTX.

24. Leadership Theory and Management (2) spring

Contemporary theories, traits and principles. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations. Includes laboratory and FTX.

101. Advanced Military Skills (3) fall

Essential junior officer skills: advanced land navigation, principles of war, small unit tactical planning, tactics and techniques of the soldier, team leading techniques, oral communications and trainer skills. Emphasizes application and field experience. Includes laboratory and FTX. Prerequisite: permission of department chairman.

102. Advanced Leadership (3) spring

Critical examination of leadership qualities, traits and principles with emphasis on military environment. Self, peer, and instructor leadership evaluation. Advanced military skills reinforced. Includes laboratory, FTX and a 5 day leadership exercise. Prerequisite: permission of department chairman.

Advanced ROTC Summer Camp

This is a six-week training program conducted at Fort Bragg, N.C. Prerequisites are completion of the basic military science courses or their equivalent and MS 101 and 102. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the industrial employment requirements of the engineering courses, CE 100, IE 100, and Mat 100. Nursing students spend 10 days at Fort Bragg and 5 weeks training in an Army hospital.

113. Military Command and Staff (3) fall

Role, authority and responsibility of military commanders and staff in personnel, logistics and training management. Staff procedures, problem solving, training methods and oral and written communications skills used in military

organizations. Includes leadership laboratory and FTX. Prerequisite: permission of department chairman.

114. Officer Responsibilities, Ethics and Military Professionalism (3) spring

Development of the Profession of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Just war theory, international law of war, and American military law. Also covered are current topics to assist cadets in making the transition to the officer corps and service on active duty or in the reserve forces. Includes leadership laboratory and FTX. Prerequisite: permission of department chairman.

118. Special Topics for the Army Officer (1) fall, spring
Seminar covering special problems and issues dealing with responsibilities of the commissioned officer as leader, manager, and mentor, not covered in other courses. Prerequisite: permission of the department chairman.

Field Training Exercise (FTX) is a two day leadership and skill training exercise conducted at a nearby U.S. Army training facility designed to teach military skills; introduce students to a military environment and teach and evaluate leadership in military situations. Mandatory for all students enrolled in military science courses.

Modern Foreign Languages

Professors. David W. P. Lewis, Dr. de l'Univ. (Sorbonne, Paris), *French*; Anje C. van der Naald, Ph.D. (Illinois), *Spanish*; Lenora D. Wolfgang, Ph.D. (Pennsylvania), *French*.
Associate professors. Marie-Sophie Armstrong, Ph.D. (Oregon), *French*; Linda S. Lefkowitz, Ph.D. (Princeton), *Spanish*; David W. Pankenier, Ph.D. (Stanford), *Chairperson*, *Chinese*; Antonio Prieto, Ph.D. (Princeton), *Spanish*; D. Alexander Waldenrath, Ph.D. (Berkeley), *German*.
Assistant professors. Marie-Helene Chabut, Ph.D. (U.C. San Diego), *French*; Constance Cook, Ph.D. (Berkeley), *Chinese*; Mary Nicholas, Ph.D. (Pennsylvania), *Russian*; Vera Stegmann, Ph.D. (Indiana), *German*.
Instructors. Jean M. O'Brien, M.A. (Michigan), *Spanish*; Edward E. Manouelian, M.A. (Harvard), *Russian*.
Adjunct lecturer. Harriet L. Parmet, M.Sc. Ed. (Temple), *Hebrew*.

Languages shown above in *italics* indicate the language normally taught by that faculty member.

Command of languages opens the door to other cultures, traditions and modes of thought and also promotes deeper insight into one's native language. Knowledge of languages is increasingly indispensable in a broad range of professions such as journalism, government, international relations, law, the armed forces and international business. A bachelor of arts degree with a major in languages can be a stepping stone to fields such as law, international careers and business. Proficiency in foreign languages is often required for graduate study and for research in science and technology. Language skills are both personally enriching and enhance career prospects.

Languages offered

Lehigh offers Mandarin Chinese, French, German, Hebrew, Japanese, Russian and Spanish.

Courses include writing and speaking, reading and listening, literature, civilization and professional areas such as business and health careers. A number of cultural courses are given in English, but most offerings stress classroom use of the language. Facilities include a German House, International House, and International Multimedia Resource Center (IMRC). Within the IMRC in Maginnes Hall are a state-of-the-art multimedia computer lab (Maginnes 470) dedicated primarily to foreign language multimedia applications and the World View Room (Maginnes 490) in which is shown a regular daily schedule

of foreign language news and feature programming received via international satellite TV networks.

Language Requirements

Requirements for the B.A. and B.S. in chemistry include German (preferred), French or Russian (see page 26). The honors major in international relations requires foreign language study. The College Scholar program in the College of Arts and Science; the major in Russian and Soviet Studies, the major in East Asian Studies, the minors in Latin American studies, Russian Area Studies, East Asian Studies and in military science require language study. Students taking the B.A. in international relations or in foreign careers are expected to study a language. Students choosing a foreign language at elementary level towards their general studies requirement in the College of Engineering must take a minimum of one year (two courses). Some doctoral programs also require foreign language competence, usually assessed by the department of modern foreign languages.

Advising. Because of the sequential nature of language study and the variety of specializations available, the department pays special attention to student advising. Students whose experience, skills and placement scores (Advanced Placement or College Board Achievement Test) do not give them a clear indication of their level of placement should consult with their instructor or the department chairperson. Faculty members responsible for more advanced advising are currently as follows: Chinese minor, Cook; French major, Wolfgang; French minor, Armstrong; German major and minor, Waldenrath; Russian minor and area studies, Nicholas; Spanish major, van der Naald; Spanish minor, Lefkowitz; and study abroad, Lewis. Both resident and faculty advisers are assigned to the German House.

Major programs. The department offers major programs in French, German and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language, as well as knowledge of its literature and culture. A period of study abroad is strongly recommended.

Double majors and Arts-Engineering majors including a language component are well received by employers. Studies in the two areas are carefully coordinated by major advisers.

Minor programs. The department offers minor programs in Chinese, French, German, Russian and Spanish and coordinates these studies with a student's major requirements in any college.

Related programs. These are available in East Asian studies, Foreign Careers, Jewish Studies, Latin American Studies and Russian and Soviet Studies.

Language of instruction. All courses are taught in the target language unless otherwise indicated. Students are thereby accustomed to considering the language as an active means of communication and not solely as an object of study.

Courses in English. The department offers elective courses in English on literary, cultural and social subjects. These courses have no prerequisite and may, in most cases, be taken to fulfill preliminary distribution requirements. One of these courses may be included in the major.

Study Abroad and Foreign Study Awards. The department encourages students of foreign languages to spend a summer, a semester, or a full year on an approved program of study abroad (see p. 37). Exchange agreements with partner institutions are continually being developed. The department offers a limited number of travel scholarships for foreign study to qualified students. Applications should be submitted by November 1 for the spring semester and by March 1 for summer or fall. For credit, transfer students must consult in advance with their major adviser, foreign language adviser, other appropriate departments, the Study Abroad Office, and when appropriate, the Office of Financial Aid.

A selective program of foreign summer internships is being developed. Lehigh programs for summer study in China and Russia are regularly offered.

Lehigh offers summer programs through the Lehigh

Valley Association of Independent Colleges (LVAIC). Programs are offered in Poitiers (France), Bonn (Germany) and Seville (Spain) for six credits each. A faculty member, acting as program director, accompanies the students. Courses are taught at intermediate and advanced levels, by qualified instructors from host institutions. Summer programs sponsored by the Lehigh-LVAIC Center for Jewish Studies include Hebrew in Israel (see page 38).

Credits and grades are fully transferable under normal LVAIC cross-registration procedures. Interested students should consult with the department of modern foreign languages, Maginnes Hall.

Campus foreign language house. The German House is recognized, together with the International House, as an important feature of campus life. Students are encouraged to participate in weekly open dinners and to consider living there.

Foreign Culture and Literature Taught in English

These courses on foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign language is not required.

Language majors may take one course taught in English by the department for credit toward a major requirement. Interested students should consult their language major advisers.

MFL 24. The Empire of the Tsar: A Journey Through 19th-Century Russia (3)

Classics of 19th-century Russia; contemporary essays and autobiographical writing; fiction.

MFL 25. Heretics and Madmen of 20th-Century Russia (3)

Major figures of 20th-century Russian literature. Heresy, dissent, and censorship, and the position of the artist in a totalitarian society; major intellectual and artistic trends of the century; Russia's intense interaction, borrowing, and influence on the West.

MFL 23. Lehigh in Russia (1-6)

A summer program in Russia, taught in English.

MFL 43. German Literature in Translation (3)

One period or theme in German literature.

MFL 51. Contemporary Hispanic-American Literature (3)

Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar and Vargas Llosa.

MFL 53. The Hispanic World and Its Culture (3)

Characteristics and values of the people of Spain and Latin America in literary works and other material. Hispanic cultural contributions to Western civilization.

MFL 61. Cultural Mosaic of Modern Israel (3) annually
Cultural and religious components of the State of Israel: creative and performing arts and sociological patterns such as population, immigration, ethnic diversity and literature.

MFL 62. The Israeli Struggle for Survival (3) Short stories in translation. National rebirth; collective society; generational conflict; Holocaust; Sephardic culture; Arab/Israeli relationships.

MFL 72. Chinese Literature in Translation (3)

Survey of a major genre of Chinese literature from earliest times through the end of the traditional period. May be repeated for credit as topic varies.

MFL 73. Introduction to Chinese Culture (3)

Traditional Chinese attitudes, values, and patterns of social interaction from a modern perspective.

MFL 74. Chinese Cultural Program (1-6)

A summer program in China, taught in English.

MFL 75. (Hist 75) Chinese Civilization (3)

Traditional Chinese customs, beliefs, values and institutions and their influence outside China. Thought, literature and the arts in the imperial age from a historical perspective.

MFL 140. (CogS 140, Anth 140) Introduction to Descriptive Linguistics (3)

Relationship between language and mind; formal properties of language; language and society; how languages change over time.

MFL 186. Russian Classics (3)

Russian literature in translation with variable topic.

Chinese

Preliminary courses. These may be replaced by advanced standing for students who qualify.

Chinese 1	Elementary Chinese I (4)
Chinese 2	Elementary Chinese II (4)
Chinese 11	Intermediate Chinese I (3)
Chinese 12	Intermediate Chinese II (3)

Requirements for the minor. A minimum of seventeen credit hours selected from Chinese 1 through 291. Not more than one MFL series course taught in English may be included.

Undergraduate Courses in Chinese

Chin 1. Elementary Chinese I (4) fall

Spoken and written Mandarin Chinese; the Pinyin transcription system used in the People's Republic of China; introduction to Chinese calligraphy, pronunciation, basic speech patterns and vocabulary. Weekly laboratory and conversation practice.

Chin 2. Elementary Chinese II (4) spring

Continuation of Chin 1; more vocabulary and sentence patterns, reading and writing Chinese characters. Weekly video laboratory and conversation practice. Prerequisite: Chin 1 or equivalent.

Chin 11. Intermediate Chinese I (3) fall

Advanced character texts and vocabulary; folktales, brief readings in Chinese. Weekly laboratory and conversation practice. Prerequisite: Chin 2 or equivalent.

Chin 12. Intermediate Chinese II (3) spring

Continuation of Chin 11; oral and written exercises. Weekly laboratory and conversation practice. Prerequisite: Chin 11 or equivalent.

Chin 41. Modern Written Chinese I (1-3) fall

Reading and writing modern colloquial Chinese; emphasis on character acquisition and written expression. Suitable especially for students who need additional work with Chinese characters to supplement existing oral skills. Prerequisite: Chin 2 or equivalent and consent of the instructor.

Chin 42. Modern Written Chinese II (1-3) spring

Continuation of Chin 41. Prerequisite: Chin 11, Chin 41 or equivalent and consent of the instructor.

Chin 141. Advanced Chinese I (3) fall

Advanced reading and oral comprehension; film, prose, poetry, journalistic Chinese. Conversation and writing practice. Prerequisite: Chin 12 or equivalent.

Chin 142. Advanced Chinese II (3) spring

Continuation of Chin 141; more advanced readings, conversation and composition. Prerequisite: Chin 141 or equivalent.

Chin 151. Chinese Short Fiction (3)

Reading of modern and contemporary short stories, essays, anecdotal literature, and other authentic texts as points of departure for conversation practice and composition.

Prerequisite Chin 142 or the equivalent, or consent of the instructor.

Chin 251. Special Topics (1-3)

Literary and linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor.

Chin 371. Special Topics (1-3)

Directed study of an author, genre, or period not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor.

French

Preliminary courses. These may be replaced by advanced standing for students who qualify.

Fren 1	Elementary French I (4)
Fren 2	Elementary French II (4)
Fren 11	Intermediate French I (3)
Fren 12	Intermediate French II (3)

Requirements for the major. A minimum of thirty credit hours is required beyond Fren 12 as follows:

Fren 143 and 144, Advanced Oral and Written French (6)

Fren 151 and 152, Survey of Literature (6)

Two or three courses from the following: Fren 146, 159, 191, or any course at the 200 level (6-9)

Three or four courses at the 300 level (9-12).

Requirements for the departmental honors major. Thirty-six credit hours are needed. Requirements are the same as for the major, plus six additional hours of advanced study on a literary or cultural subject normally taken as an honors thesis (Fren 371) and a 3.20 average in the major.

Recommended related courses. Students majoring in French are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credit hours are required above Fren 12 follows:

Fren 143 (3)

Two or three of 144, 146, 151, 152, 159, 191, or any course at the 200 level (6-9).

One or two courses at 300 level. (3-6)

Requirements for advanced courses. Except where otherwise noted, 200- or 300-level courses are open to students having completed six credit hours of French beyond Fren 12. Exceptions require the consent of the instructor.

Study Abroad. A period of study in a French-speaking country is strongly encouraged for qualifying students. Agreements are in effect with Paul Valéry University, Montpellier and Ecole Supérieur de Commerce, Poitiers. For these and LVAIC summer programs, both grades and credits are transferred. For other approved programs consult Center for International Studies.

Language of instruction. Courses are normally conducted in French.

Undergraduate Courses in French

Fren 1. Elementary French I (4) fall

Basic conversational French, illustrating essential grammatical principles, reading simple texts and writing. Language laboratory video.

Fren 2. Elementary French II (4) spring

Continuation of Fren 1. Prerequisite: Fren 1 or appropriate Achievement Test score before entrance, or consent of instructor.

Fren 11. Intermediate French I (3) fall

Completion of grammar and grammar review. Video, readings and discussion. Prerequisite: Fren 2 or appropriate Achievement Test score before entrance, or consent of instructor.

Fren 12. Intermediate French II (3) spring

Readings and discussion. Prerequisite: Fren 11 or

appropriate Achievement Test score before entrance, or consent of instructor.

Fren 41. French Pronunciation (1)

Correct pronunciation of French: the obstacles commonly encountered by American speakers. Articulation, rhythm and pitch. Introduction to the International Phonetic Alphabet. Laboratory work. Prerequisite: any French course previously or concurrently.

Fren 42. Grammar (1)

Intensive review of the fundamentals of French grammar. Prerequisite: Equivalent of Fren 2. May be taken for credit only if no previous degree credit in French has been granted; may be audited by others.

For Advanced Undergraduates And Graduate Students

Fren 143. Advanced Written French (3)

Intensive practice in written French and introduction to literary criticism. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor.

Fren 144. Advanced Oral French (3)

Emphasis on oral work. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor.

Fren 146. French for Business and Foreign Careers (3)

For students who want "professional" French but are uncertain of their readiness for highly specialized material. Intensive revision of grammar, reading of simple contemporary texts, conversation, composition and letter writing. Prerequisite: Fren 12 or consent of instructor. Lewis

Fren 151. Survey of French Literature I (3)

From the Middle Ages through the 18th century. Prerequisite: Fren 143 or 144 or consent of instructor. Wolfgang

Fren 152. Survey of French Literature II (3)

Representative works of the 19th and 20th centuries. Prerequisite: Fren 143 or 144 or consent of instructor. Armstrong

Fren 159. The French-Speaking World and Its Culture (3)

Cultural, social and artistic development of France and the French-speaking world. Prerequisite: Fren 143 or 144 or consent of instructor. Armstrong

Fren 181. French Cultural Program (1-6)

A summer program abroad. Formal instruction in the French language and direct contact with the people and their culture during one or two months in a French-speaking country. (For LVAIC courses, see Fren 191, 291 below.)

Fren 223. Love and the French Novel (3)

Representative works from each period of French literature from *Tristan et Iseult* and *La Princesse de Cleves* to Gide's *L'Immoraliste*. Style, themes, myths and story patterns are analyzed. Prerequisite: any of Fren 143, 144, 151, 152 or 159. Wolfgang

Fren 224. Great French Plays (3)

Evolution of French drama through study of master works, from the 17th century to the present. Prerequisite: any of Fren 143, 144, 151, 152 or 159.

Fren 268. World Literature Written in French (3)

Major authors from areas outside Europe, such as Canada, Africa, and the Caribbean. Prerequisite: any of Fren 143, 144, 151, 152 or 159.

Fren 271. Readings (3)

Study of the works of some author or group of authors or a period, or of a literary theme. May be repeated once for credit. Prerequisite: Fren 143 or 144, plus 151 or 152 or consent of instructor.

Fren 281. French Cultural Program (1-6)

A program in a French-speaking country offering formal language courses and cultural opportunities. (For IVAIC courses, see Fren 291 below.) Prerequisite: consent of instructor.

Fren 301. Advanced Composition and Translation (3)

Techniques of translation. Literary, political, and technical texts. Essay-writing techniques and free composition. Prerequisite: a 200-level course or consent of instructor. Lewis

Fren 302. Medieval French Literature (3)

Introduction to Old French from *La Chanson de Roland* to Francois Villon. Wolfgang

Fren 303. Arthurian Romances (3)

Medieval romances of Arthur, Lancelot and the Holy Grail. Readings and discussion of the first literary works dealing with Arthurian themes. Wolfgang

Fren 304. Renaissance Poetry (3)

Study of the major poets of the period, including Ronsard and duBellay. Wolfgang

Fren 305. Prose in the 16th Century (3)

Analysis of fiction, memoirs, historical documents, including the works of Rabelais, Montaigne, and Marguerite de Navarre. Wolfgang

Fren 311. French Classicism (3)

French classical theater, novel and criticism, with emphasis on Corneille, Racine, Moliere, Pascal, Lafayette, Malherbe and Boileau. Chabut

Fren 313. The Age of Enlightenment (3)

The *Philosophes* and *Encyclopedes* of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu and Diderot. Chabut

Fren 315. 19th Century Poetry (3)

Parnassian, Symbolist and Post-Symbolist eras. Lewis

Fren 317. The Romantic Movement (3)

The Romantic movement in France with readings from its principal exponents. Lewis

Fren 318. Drama in the Twentieth Century (3)

Contemporary French drama with an analysis of its origins and movements. Armstrong, Lewis

Fren 319. Twentieth Century Novel and Poetry (3)

Detailed study of representative major works. Armstrong

Fren 320. Contemporary French Fiction (3)

Reading and discussion of contemporary works of fiction (post-1980). Study of how these works fit into the context of French literature and relate more specifically to major literary currents of the 20th century. Armstrong

Fren 345. Advanced French for Business and Foreign Careers (3)

Understanding and writing French for business and international affairs. Readings and oral presentations of current interest, with technical vocabulary (marketing, finance, industry, agriculture, communications, transport, real estate, economic relations, environment, etc). Prerequisite: any of Fren 143, 144, 146, 159 or consent of instructor. Lewis

Fren 369. Readings (3)

Advanced study of an author, period or theme. Topics vary. May be repeated once for credit.

Fren 370. Internship (1-6)

Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in French-speaking countries. Assigned readings, written reports, and employer

performance evaluations are required. Prerequisites: French 143 or 144 and approval of French study abroad advisor.

Fren 371. Independent Study (1-6)

Special topics under faculty guidance, including honors thesis. May be repeated once for credit. Prerequisite: consent of instructor.

German

Preliminary courses. These may be replaced by other courses when a student qualifies for advanced standing.

Germ 1	Elementary German I (3)
Germ 2	Elementary German II (3)
Germ 11	Intermediate German I (3)
Germ 12	Intermediate German II (3)

Requirements for the major. A minimum of thirty credits beyond Germ 12 of which three credits must be a junior year writing course in the German section. Emphasis should be upon 200- and 300-level courses.

Requirements for the departmental honors major.

Requirements are the same as for the major, plus: two additional advanced courses at the 300 level; dissertation or comprehensive examination (written or oral); an average of 3.50 in courses in the major.

Recommended related courses. Students majoring in German are urged to take courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credits above Germ 12 are required including at least one at 300-level.

Requirements for advanced courses. The prerequisite for all 200-level courses is at least one three-credit course taught in German beyond Germ 12 or equivalent. The prerequisite for all 300-level courses is at least two three-credit courses beyond Germ 12 (course in English excluded) or equivalent. Prerequisite may be waived by consent of the chairperson.

Language of instruction. Courses are normally conducted in German. Courses conducted in English are listed under MFL courses.

Undergraduate Courses in German

Germ 1. Elementary German I (3)

Fundamentals of German; reading of simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required.

Germ 2. Elementary German II (3)

Continuation of German 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week. Prerequisite: Germ 1, or two units of entrance German, or consent of the chairperson.

Germ 5. German Pronunciation (1)

Practice in pronunciation, articulation, rhythm and pitch. Includes laboratory practice. Strongly recommend for all students of the language at all levels.

Germ 11. Intermediate German I (3)

Review of grammar, composition, reading of intermediate texts, vocabulary building. Prerequisite: Germ 2 or four units of entrance German or consent of chairperson.

Germ 12. Intermediate German II (3)

Continuation of Germ 11. Prerequisite: Germ 11 or consent of chairperson.

Germ 63. Introduction to German Culture (3)

Lectures, readings and discussion of selected aspects of German culture. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 65. Introduction to the German Literary Tradition (3)
Representative works from one or more of the major periods

of German literature. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 67. Conversation and Composition (3)

Intensive practice in oral and written German. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 81. German Cultural Program (1-6)

Summer program abroad. Formal instruction in the language and the culture of a German speaking country.

For Advanced Undergraduates And Graduate Students

Germ 201. Survey of German Literature I (3)

German literature to the second half of the 18th century. Readings, literature and discussion of representative works.

Germ 202. Survey of German Literature II (3)

From the Age of Goethe to the present. Readings, lectures and discussion of representative works.

Germ 211. Introduction to German Drama (3)

Drama as a literary genre; plays from various periods of German Literature.

Germ 214. Goethe's "Faust" (3)

Study of Goethe's play with an introduction to the Faust tradition.

Germ 241. Advanced Composition and Conversation (3)
Conducted in German.

Germ 250. Special Topics (1-3)

Literary and linguistic topics not covered in regular courses. May be repeated for credit.

Germ 281. German Cultural Program (1-6)

Study abroad. Formal instruction in German and direct contact with the people and their culture during at least one month in a German-speaking country. Prerequisites: Germ 63, 65, or 67, or consent of the chairperson.

Germ 301. Medieval German Literature (3)

Lectures and readings in medieval literature in translation. Introduction to Middle High German.

Germ 302. Renaissance, Reformation and Baroque (3)

Writers and literary movements from the end of the Middle Ages through the Baroque.

Germ 303. German Romanticism (3)

Early and late Romanticists.

Germ 304. Literature of the GDR (3)

Representative East-German writers.

Germ 305. 20th-Century German Literature (3)

Topics in German literature of the 20th century.

Germ 325. 19th-Century German Literature (3)

Representative writers of post-Romanticism.

Germ 341. Advanced Phonetics, Linguistics, Composition, Conversation and Translation (3)

Essay writing and translation from and into German.

Germ 344. The Age of Enlightenment and Classicism (3)

Selected works of the period.

Germ 350. Special Topics (1-3)

Literary or linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: permission of the chairperson.

Germ 370. Internship (1-6)

Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in German-speaking countries.

Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: Germ 67 and/or approval of the staff in German.

Hebrew

The department offers courses both separately and in the context of the Jewish Studies minor (see page 28).

Language of instruction. Courses are normally conducted in Hebrew. A course in Hebrew culture taught in English is listed under Foreign Culture above, MFL 61 & 62.

Hebr 1. Elementary Modern Hebrew I (3) fall

Classroom and laboratory instruction to develop hearing, speaking, reading and writing the language. Cultural, ethnic and religious dimensions of Israeli society. Tapes, textual materials, short stories. No previous study of Hebrew required.

Hebr 2. Elementary Modern Hebrew II (3) spring

Continuation of Hebrew 1 utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading and vocalized stories; written exercises; tapes; short stories. Prerequisite: Hebr 1 or its equivalent.

Hebr 11. Intermediate Modern Hebrew I (3) fall

Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: Hebr 2 or qualifying examination.

Hebr 12. Intermediate Modern Hebrew II (3) spring

Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: Hebr 11 or approval of the department chairperson.

Japanese

Jpns 1. Elementary Japanese I (4) fall

Introduction to the oral and written language with emphasis on spoken Japanese and syllabaries. Language laboratory.

Jpns 2. Elementary Japanese II (4) spring

Continuation of Japanese 1. Prerequisite: Japanese 1 or equivalent.

Jpns 11. Intermediate Japanese I (3) fall

Continuation of Japanese 2. Structural patterns in both spoken and written languages. 150 kanji (Chinese characters). Prerequisite: Jpns 2 or equivalent.

Jpns 12. Intermediate Japanese II (3) spring

Continuation of Japanese 11. Prerequisite: Japanese 11 or equivalent.

Jpns 141. Advanced Japanese I (3) fall

Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: Jpns 12 or equivalent.

Jpns 142. Advanced Japanese II (3) spring

Continuation of Jpns 141. Prerequisite: Jpns 141 or equivalent.

Russian

Requirements for minor. Eighteen credit hours of Russian are required not including MFL 21, 22, 321 or 322. For Russian studies minor, see page 29.

Language of instruction. Courses are normally conducted in Russian. Courses in Russian culture taught in English are listed under Foreign Culture above, MFL 21, 22.

Russ 1. Elementary Russian I (4) fall

Classroom and laboratory, audio and video introduction to

the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing.

Russ 2. Elementary Russian II (4) spring
Continuation of Russ 1. Prerequisite: Russ 1 or two years of entrance Russian.

Russ 11. Intermediate Russian I (3) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russ 2 or three units of entrance Russian or equivalent.

Russ 12. Intermediate Russian II (3) spring
Continuation of Russ 11. Prerequisite: Russ 2 or 11, or equivalent.

Russ 31. Russian in the Real World I (3)
Readings and conversations about selected nonliterary topics including the social and natural sciences, business, economics, the environment, current political events in Russia and throughout the former Soviet Republics.

Russ 32. Russian in the Real World II (3)
A continuation of Russ 31.

Russ 141. Conversation and Composition I (3) fall
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russ 12, or three units of entrance Russian.

Russ 142. Conversation and Composition II (3) spring
Continuation of Russ 141. Prerequisite: Russ 141.

Russ 203. The Icon and the Axe: Intellectual History of Medieval Russia (3)
Survey of medieval Russian history from the eleventh to the late seventeenth century. Historical works on the period, early Russian epics, chronicles, apocryphal legends, saints' lives, sermons, epistles, lays, folk poetry, and Russian picaresque tales. Development of ecclesiastical art and architecture. Influence of Russian culture Classical, Byzantine, and European models.

Russ 204. The Myths of the Slavs: Folklore and Literature (3)
Distinction between "folklore" and "literature." Study of Russian, Ukrainian, and Belarussian tales, legends, riddles, sayings and heroic poems.

Russ 221. The Emergence of Russian Fiction: The 19th Century (3)
Development of genre; the role of the reader; symbolic significance of the fictional space each author creates, from the claustrophobic slums of Petersburg to the endless reaches of the steppe. Readings include Pushkin's Eugene Onegin, Lermontov's A Hero of Our Time, Gogol's Dead Souls, and Dostoevsky's White Nights.

Russ 222. Discourse and Dissent in 19th-Century Russian Fiction (3)
Political, philosophical, and moral questions; heroes of the novels of the time.

Russ 215. Russian Classics: Russian Literature with Variable Topic and Credit. (3-4)

Russ 220. The Decadent Imagination in Russian Literature: 1890-1915 (3)
Poetry, fiction, and drama of Russian symbolism and other related avant-gardisms of the fin-de-siecle in the context of contemporary European influences.

Russ 221. The End of the Empire: Russian Literature Since 1985 (3)
Recent developments in Russian fiction. Trends in the pictorial arts, film, prose and poetry.

Russ 230. The Gathering Storm: The Social Context of Russian Pre-Revolutionary Culture 1880-1917 (3)
Russia on the brink of revolutionary upheaval; historical documents, memoirs, and fiction.

Russ 251. Special Topics (3) fall
Intensive study of literary or linguistic topics. Prerequisite: Russ 42. May be repeated for credit. Nicholas

Russ 252. Special Topics (3) spring
Intensive study of literary or linguistic topics. Prerequisite: Russ 42 or 251. May be repeated for credit. Nicholas

Russ 311. Utopia in Power: Russian Literature After the Revolution (3)
Innovative Russian writers of the 1920's. Themes and techniques developed by writers to deal with the problems of society after the revolution of 1917.

Russ 312. Utopia in Retreat: Fifty Years of Russian Literature (3)
Evolution of Russian literature from the beginning of Socialist Realism to the advent of openness in the 1980s. Responses to the pressure of political events and creative needs.

Russ 370. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Russian-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Russ 41 or 42 and approval of faculty committee on internship.

Russ 391. Special Topics (1-3)
Independent study or research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisites: undergraduate degree and consent of chairperson. Nicholas

Spanish

Preliminary courses. These may be replaced by other courses if students achieve advanced standing.

Span 1	Elementary Spanish I (4)
Span 2	Elementary Spanish II (3)
Span 11	Intermediate Spanish I (3)
Span 12	Intermediate Spanish II (3)

Requirements for the major. A total of thirty credit hours are required above Span 12 as follows: Span 141, 142 or 255, 151, 152. Span 191 or 291 may be considered.

Four courses at the 300-level: at least two must be selected from Peninsular literature and at least two from Spanish American literature, the remaining two courses at the 100-level and above.

Requirements for departmental honors major. Thirty-six credit hours are required above Span 12 as follows: thirty credits, as for the major; six additional credit hours on the 300-level; a 3.50 average in the major.

Requirements for the minor. Fifteen credits are required above Span 12, as described for three minor tracks. *Spanish American Track.* Span 141, 142 or 255, 152, a 300-level course in Spanish American literature, one course at the 100-level or above.

Peninsular Track. Span 141, 142 or 255, 151, a 300-level course in Peninsular literature, one course at the 100-level or above.

Professional Track. Span 141, 142 or 255, 211, 151 or 152, one course at the 100-level or above.

Recommended related courses. Students majoring in Spanish are urged to take courses on related subjects inside or outside the department, as approved by their adviser.

Requirements for advanced courses. The normal prerequisite for 200- and 300-level literature courses in Spanish is Span 151 and/or 152. Exceptions require consent of chairperson.

Language of instruction. Courses are normally conducted

in Spanish. Culture courses taught in English are listed under Foreign Culture and Literature Taught in English.

Undergraduate Courses in Spanish

Span 1. Elementary Spanish I (4) fall

Basic conversational Spanish illustrating essential grammatical principles. Reading of simple texts and writing. Lab required.

Span 2. Elementary Spanish II (4) spring

Continuation of Span 1. Prerequisite: Span 1 or equivalent.

Span 11. Intermediate Spanish I (3) fall

Grammar review. Contemporary readings. Practice of speaking and writing. Prerequisite: Span 2 or equivalent.

Span 12. Intermediate Spanish II (3) spring

Grammar review. Readings of Spanish and Latin American authors. Emphasis on acquiring oral and written fluency. Prerequisite: Span 11 or equivalent.

Span 131. Communicating in Spanish for Medical Personnel (1-3)

For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice. Prerequisite: Span 12 or equivalent. Lefkowitz

Span 133. Phonetics and Pronunciation (3)

Comparison of Spanish and English sounds; descriptions of Spanish vowels and consonants in their various positions. Oral practice in Language Laboratory. Special emphasis on accent and intonation patterns. Prerequisite: Span 2. Staff

Span 141. Advanced Grammar (3) fall

Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Prerequisite: Span 12 or equivalent. Staff

Span 142. Advanced Conversational Spanish (3) spring

Conversational practice stressing the building of vocabulary, based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Enrollment limited to 15. Prerequisite: Span 141 or equivalent. Staff

Span 151. Cultural Evolution of Spain (3) fall

The historical and cultural evolution of Spain. Discussion of major literary works in their cultural and historical contexts. Prerequisite: Span 141 or 142 or consent of instructor. Lefkowitz or van der Naald

Span 152. Cultural Evolution of Latin America (3)

The historical and cultural evolution of Latin America. Discussion of representative literary works in their cultural and historical contexts. Prerequisite: Span 141, 142 or consent of instructor. Prieto

Span 199. Special Topics (3)

For students who take a course, not offered by Lehigh, at another institution. May be repeated once for credit. Prerequisite: approval of faculty.

For Advanced Undergraduates And Graduate Students

Span 211. Practical Business Spanish (3)

For students with a basic knowledge of Spanish: the language in business, law, international and social relations. Letter-writing, comprehension of technical texts, specialized professional vocabulary and review of grammar. Prerequisite: Span 141 or equivalent. Lefkowitz

Span 212. Writing Skills (3)

Improving writing proficiency through practice in composition and translation. Prerequisite: Span 141 or equivalent. Lefkowitz

Span 231. Spanish American Literature (3)

Literature of the pre-Colombian, conquest and colonial periods. Oral and written reports. Prerequisite: Span 151 or 152.

Span 255. Improvisational Theater Games in Spanish

For students who have some fluency in the language and who wish to practice and improve their oral Spanish in a creative setting. Enrollment limited to 15. Prerequisite: Span 141 or equivalent. van der Naald

Span 263. The Spanish American Short Story (3)

Comparative study of the literary problems posed by the work of significant short-story writers such as Quiroga, Borges, Cortázar, Ribeyro, and others. Prerequisite: Span 152. Prieto

Span 265. Spanish and Latin American Cinema (3) fall

Oral discussion and written analysis of selected films. Prerequisite: Span 142 or equivalent. van der Naald.

Span 281. Spanish Cultural Program (1-6)

A program abroad. Formal instruction in Spanish grammar, conversation and culture during one or more months in Spain or Latin America on an approved program. (For IVAIC courses, see Span 191 and 291 below.) Prerequisite: Span 12.

Span 303. Don Quijote (3)

Reading and critical analysis. Prerequisite: Span 151. Lefkowitz

Span 305. Spanish Literature of the Middle Ages (3)

Reading and discussion of outstanding works such as *El Cid*, *El Libro de Buen Amor* and *La Celestina*. Topics vary. Prerequisite: Span 151. Lefkowitz

Span 308. Peninsular Literature Since 1939 (3)

Reading and discussion of representative contemporary Spanish poets, playwrights and novelists. Prerequisite: Span 151. van der Naald

Span 310. Literature of 19th-Century Spain (3)

Poetry, novels and plays that exemplify the literary movements of Romanticism, Realism and Naturalism. Topics vary. Prerequisite: Span 151. van der Naald

Span 317. Twentieth-Century Spanish Theater (3)

Prerequisite: Span 151. van der Naald

Span 320. Literature of the Spanish Caribbean (3)

Study of representative works with emphasis on Cuba and Puerto Rico. Writers include Barnet, Carpentier, Sanchez, and Rodriguez Julia. Prerequisite: Span 152. Prieto

Span 321. Children and Adolescents in Contemporary Spanish American Literature (3)

Discussion of narrative techniques and the category of the self as they relate to the images of adolescence and childhood in works by such authors as Vargas Llosa, Reinaldo Arenas, Jose Bianco, and Silvina Ocampo. Prerequisite: Span 152. Prieto

Span 322. The Short Novel in Contemporary Spanish American Literature (3)

Reading and discussion of representative works by Garcia Marquez, Onetti, Rulfo, Bioy Casares, and others. Prerequisite: Span 152. Prieto

Span 323. Literature and Revolution in Contemporary Cuba (3)

Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Norberto Fuentes, Benítez Rojo, Cabrera Infante). Discussion of problems raised by the social function of intellectuals and of literature, as they relate to themes, modes of writing, genres. Prerequisite: Span 152. Prieto

Span 324. Marginal Groups in Spanish American Literature (3)

Reading and discussion of representative works that portray those who have been excluded from the main culture. Authors to be read are Hernández, Sarmiento, Alegría, Guillén, and Carpentier. Prerequisite: Span 152. Prieto

Span 379. Internship (1-6)

Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Spanish-speaking countries or agencies serving the Hispanic community. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Span 141 or 142 and approval of faculty.

Span 391. Special Topics (3)

Study of an author, theme or period. Topics vary. May be repeated once for credit. Prerequisites: Span 151 or 152 and at least one 300-level course. Staff

Study Abroad Programs

These courses are offered by Lehigh or under the cooperation agreement with the Lehigh Valley Association of Independent Colleges. Summer or semester study abroad at approved programs may be incorporated into foreign language majors and minors with the permission of the appropriate advisor to a maximum of 15 credits toward the major and 7 credits toward the minor.

Chinese**Chin 91. Chinese Language and Culture Abroad (1-6)**

Intensive study of conversational Chinese in China; reading, development of writing skills and selected aspects of Chinese culture.

Chin 191. Intermediate Chinese Language and Culture Abroad (1-6)

Alternative to Chin 91 at the intermediate level.

Chin 291. Advanced Chinese Language and Culture Abroad (1-6)

Summer or semester study in China at advanced level.

French**Fren 191. French Language and Culture II Abroad (1-6)**

Intensive practice in France of conversational French, rapid review of basic grammar, reading and analysis of moderately difficult texts, development of writing skills, supplemented by study of selected aspects of contemporary French civilization. Prerequisites: consent of chairperson and proficiency examination in France.

Fren 291. French Language and Culture III Abroad (1-6)

Intensive practice in France of spoken and written French, aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts, supplemented by in-depth study of selected aspects of contemporary French civilization. Prerequisites: consent of chairperson and proficiency examination in France.

German**Germ 191. German Language and Culture II Abroad (1-6)**

Intensive practice in Germany of conversational German, rapid review of basic grammar, reading and analysis of moderately difficult texts, development of writing skills, supplemented by the study of selected aspects of contemporary German civilization. Prerequisites: consent of chairperson and proficiency examination in Germany.

Germ 291. German Language and Culture III Abroad (1-6)

Intensive practice in Germany of spoken and written German, aimed at providing the student with extensive proficiency of expression and the ability to discriminate

language usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts, supplemented by in-depth study of selected aspects of contemporary German civilization. Prerequisites: consent of chairperson and proficiency examination in Germany.

Hebrew

For courses in Israel including study of Hebrew, see Jewish Studies, page 28.

Japanese**Jpns 91. Japanese Language and Culture Abroad (1-6)**

Intensive study of conversational Japanese in Japan; development of reading and writing skills; selected aspects of Japanese culture.

Jpns 191. Intermediate Japanese Language and Culture Abroad (1-6)

Alternative to Jpns 91 at the intermediate level.

Jpns 291. Advanced Japanese Language and Culture Abroad (1-6)

Summer or semester study in Japan at advanced level on selected topics.

Russian**Russ 91. Russian Language and Culture Abroad (1-6)**

Intensive practice in the USSR of conversational Russian, reading, development of writing skills and selected aspects of Russian culture.

Russ 191. Intermediate Russian Language and Culture Abroad (1-6)

Alternative to Russ 91 at a more advanced level.

Russ 291. Advanced Russian Language and Culture Abroad (1-6)

Summer or semester study in the USSR at advanced level on selected topics.

Spanish**Span 191. Spanish Language and Culture II Abroad (1-6)**

Intensive practice in Spain of conversational Spanish, rapid review of basic grammar, the reading and analysis of moderately difficult texts, development of rudimentary writing skills, supplemented study of selected aspects of contemporary Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain.

Span 291. Spanish Language and Culture III Abroad (1-6)

Intensive practice in Spain of spoken and written Spanish aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts. Supplemented by in-depth study of selected aspects of contemporary Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain.

Molecular Biology

Professors. Jeffrey A. Sands, Ph.D. (Penn State), *chairperson*; John H. Abel, Ph.D. (Brown); Steven Krawiec, Ph.D. (Yale).

Associate professors. Barry Bean, Ph.D. (Rockefeller); Vassie C. Ware, Ph.D. (Yale).

Assistant professors. Agnes Ayme-Southgate, Ph.D. (Geneva); Lynne Cassimeris, Ph.D. (North Carolina); Michael R. Kuchka, Ph.D. (Carnegie-Mellon).

Molecular Biology has emerged as a major scientific discipline during the second half of the 20th century. This rapidly developing field encompasses the study of life at the molecular and cellular levels. The Department of Molecular Biology consists of faculty members who teach and do

research in the areas of genetics, cell biology, developmental biology, virology, and the molecular biology of cancer and other serious diseases.

The Department of Molecular Biology offers programs of study leading to the degrees of B.A. or B.S. in Molecular Biology and B.A. or B.S. in Biology. The majors in Molecular Biology, described below, provide an excellent background for entrance into a career in this exciting field or in medicine. For students who wish a more broad based program in the life sciences, the B.A. or B.S. in Biology is a more appropriate major. The required courses for the major in biology are listed under the Biological Sciences section of this catalog.

Requirements for the B.A. in Molecular Biology

College and University requirements (see page 25 of University catalog).

A.	A&S 1, Choices and Decisions	1 credit
B.	College Seminar	3 credits
C.	English composition	6 credits
D.	Mathematical sciences	3-4 credits*
E.	Sciences	9-12 credits*
F.	Social sciences	9-10 credits
G.	Humanities	9-12 credits+

The BA in Molecular Biology

Molecular biology (28 credit hours)

MBio 31, 32	Introduction to Cell & Molecular Biology (3) and Lab (1)
MBio 101, 102	Genetics (3) and Lab (1)
MBio 324, 325	Bacteriology (3) and Lab (1)
MBio (Chm) 371	Biochemistry (3)
MBio 345, 346	Molecular Genetics (3) and Lab (1)
MBio 367	Cell Biology (3)
MBio	electives (6 credit hours)

Mathematics (8-9 credit hours)

Math 21 and 22	(8) or Calculus
Math 41, 43 and 44	(9) Calculus

Chemistry (13 credit hours)

Chm 21, 22	Introduction to Chemical Principles (3) and Lab (1)
Chm 51, 52, 53, 58	Organic Chemistry and Lab (8)

Physics (5 credit hours)

Phy 11, 12	Introductory Physics and Lab (5)
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Physics/chemistry elective (3 or 4 credit hours)

Chm 31 or	Chemistry Equilibria (3)
Chm 194 or	Physical Chemistry (3)
Phy 13, 14	Introductory Physics II and Lab (4)

Philosophy (3 credit hours)

Phil 128	Philosophy of Science (3)
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Natural science, mathematics, or computing science (3 credit hours)

*The mathematics distribution requirement is satisfied by courses required in the major.

*The science distribution requirement is satisfied by courses required in the major.

+Three credit hours of the humanities distribution requirement are satisfied by the philosophy requirement in the major.

Requirements for the B.S. in Molecular Biology

College and university requirements (28 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8, 10	Composition and Literature (3)
A&S 1	Choices and Decisions (1)

Non-science
electives

College Seminar (3) (18), to be broadly distributed in fields of thought other than natural sciences and mathematics, including 9 credit hours each in the humanities and social sciences.

Major Program (93 credit hours)

Mathematics (12 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
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Chemistry (19 credit hours)

Chm 21	Introductory Chemical principles (4)
Chm 22	Chemical Principles Laboratory (1)
Chm 51, 52	Organic Chemistry (6)
Chm 53, 58	Organic Chemistry Laboratory (2)
Chm 31, 194 (or 187)	Chemical Equilibria in Aqueous Systems and Physical Chemistry for Biological Sciences (6)

Physics (9-10 credit hours)

Phy 11	Introductory Physics I (4)
Phy 12	Introductory Physics Laboratory I (1)
Phy 13 (or 21)	Introductory Physics II (3 or 4)
Phy 14 (or 22)	Intro. Physics Lab II (1)

Natural sciences, mathematics or computing science (6 credit hours)
electives (6)

Free electives (12 credit hours)

Molecular Biology (35-37 credit hours)

MBio 31	Intro. to Cell and Molecular Biology (3)
MBio 32	Intro. Cell/Molecular Laboratory (1)
MBio 101	Genetics (3)
MBio 102	Genetics Laboratory (1)
MBio 324	Bacteriology (3)
MBio 325	Bacteriology Laboratory (1)
MBio 345	Molecular Genetics (3)
MBio 346	Molecular Genetics Laboratory (1)
MBio 367	Cell Biology (3)
MBio (Chm) 371	Elements of Biochemistry I (3)
MBio (Chm) 372	Elements of Biochemistry II (3)
Elect	Approved Molecular Biology Electives (10-12)

Recommended sequence for the B.S. in Molecular Biology

freshman year

MBio 31	Intro. to Cell and Molecular Biology (3)
MBio 32	Intro. Cell/Molecular Laboratory (1)
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chm 21, 22	Introductory Chemical Principles and Laboratory (5)

sophomore year

MBio 101	Genetics (3)
MBio 102	Genetics Laboratory (1)
Math 23	Analytic Geometry and Calculus III (4)
Chm 51, 52	Organic Chemistry (6)
Chm 53, 58	Organic Chemistry Laboratory (2)
Phy 11, 12	Introductory Physics I and Laboratory (5)

Phy 13, 14 (or 21, 22)	Introductory Physics II and Laboratory (4 or 5)
junior year	
MBio 324	Bacteriology (3)
MBio 325	Bacteriology Laboratory (1)
MBio 345	Molecular Genetics (3)
MBio 346	Molecular Genetics Laboratory (1)
Chm 31	Chemical Equilibria in Aqueous Systems (3)
Chm 371, 372	Elements of Biochemistry I and II (6)
Elect	Approved Molecular Biology Electives (3-4)
senior year	
Elect	Approved Molecular Biology electives (7-8)
MBio 367	Cell Biology (3)
Chm 194	Physical Chemistry for Biological Sciences (3)
Elect	Natural science electives (6)

Departmental Honors

A student may apply for admission to the departmental honors program through a potential thesis advisor. Detailed requirements for the program may be obtained from the advisor or from the department office.

Molecular Biology Minor

The molecular biology minor program consists of MBio 31 (3), 32 (1), 101 (3), 102 (1), 345 (3), 346 (1), and a minimum of 4 additional credits of MBio coursework above the 100 level. Collateral coursework must include Math 41 or 21 (3 or 4 credit hours), Chm 21 (4) and Chm 22 (1).

Undergraduate Courses in Molecular Biology

1. Molecular Biology and Society (3)

Basic and applied molecular biology. Gene cloning; human gene therapy, cancer; reproduction; contraception; viral infections including AIDS. Ethical considerations. For non-science majors. May not be used in satisfaction of life science major or minor programs.

7. Human Reproduction (3)

Basic and applied human reproductive biology for non-science majors. May not be used in life science major or minor programs.

31. Introduction to Cell and Molecular Biology (3)

Introduction to the structure, function, and evolution of cells at the level of molecules, organelles, and differentiated cell types. Includes basic structure and expression of genes, cell physiology, and the molecular/cellular basis of disease and immunity. Prerequisite: Chm 21 previously or concurrently.

32. Introduction to Cell/Molecular Biology Laboratory (1)

Experiments, observations, and discussions related to the principal topics covered in MBio 31. Corequisite: MBio 31.

101. Genetics (3)

The structure, function, and continuity of hereditary information. Major topics include mechanisms and regulation of gene expression, replication and transmission of genetic material, mutation, and organization and change of genetic material in populations. Prerequisites: MBio 31.

102. Genetics Laboratory (1)

Laboratory work that demonstrates major principles of genetics: included are experiments on microorganisms and the common fruit fly *Drosophila melanogaster*. Prerequisite: MBio 101, preferably concurrently.

202. Biomedical Externship (1 or 2)

Analysis of individualized experiences at external biomedical clinical or research sites. Limited enrollment. May not be taken for pass-fail grading. Prerequisite: Consent.

221. Human Histology (3)

Human tissues and organs. Emphasis on structural and functional interrelationships of cells. Disease states and pathologies. Two lectures and one laboratory. Prerequisite: MBio 101.

225. Introduction to Molecular Biological Research (3)

Literature and methods of research in area of department faculty expertise. Requires development of detailed proposal for research to be performed in senior year. Prerequisites: Major in molecular biology or biology; junior standing; GPA of 3.0 in major; and consent of the department chairperson.

229. Immunology (3)

Distinction of "self" and "non-self" through humoral and cellular mechanisms. Antigens; biochemical structures; cellular mechanisms; genetic control and processing; phylogenetic distribution; diseased states. Prerequisite: MBio 101.

251. Writing and Molecular Biology (3)

A course designed to acquaint students with some of the intellectual foundations of science, with attention to the distinctiveness of molecular biology. Format includes readings, intensive writing, extemporaneous speaking, and discussion. Prerequisite: MBio 101.

261. Special Topics in Molecular Biology (1-3)

Research, conferences and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: consent of the department chairperson.

For Advanced Undergraduates and Graduate Students

324. Bacteriology (3)

The structure, physiology, growth, genetics and taxonomy of prokaryotes. Prerequisites: Chm 51 and MBio 101. Corequisite: MBio 325.

325. Bacteriology Laboratory (1)

Standard procedures and metabolic tests used in determinative bacteriology; aseptic technique, sterilization, enumeration, and control of bacterial growth; other selected topics. Corequisite: MBio 324.

345. Molecular Genetics (3)

The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and eukaryotes and their viruses; techniques for intervention into genetic organization and expression. Prerequisite: MBio 101.

346. Molecular Genetics Laboratory (1)

Laboratory experiments related to the topics covered in MBio 345. Emphasis is on molecular characterization of DNA and the principles of gene isolation and transfer. Corequisite: MBio 345.

347. Advanced Topics in Genetics (3)

Lectures and student projects on selected aspects of genetics such as the genetics and evolution of particular organisms, regulation of gene expression and transmission, human genetics, gene therapy, etc. Prerequisites: MBio 345 or consent of department chairperson.

353. Virology (3)

Structure and replication of viruses, including those infecting bacteria, plants and animals. Emphasis on the organization, replication, and regulation of expression of viral genomes and on the mechanisms of virus assembly and

release. Special attention given to human pathogenic viruses. Prerequisite: MBio 101.

356. Human Genetics and Reproduction (3)

Processes and mechanisms of human heredity. Emphasis at the cellular and molecular levels. Analysis, organization, expression, and evolution of human genome. Genetic aspects of reproduction and development, mapping human chromosomes, cell hybridation, molecular analysis of gene structure and function, behavior and intelligence, primate origins and evolution, immunogenetics, cancer and oncogenes, genetic technologies. Prerequisite: MBio 101.

367. Cell Biology (3)

Molecular aspects of cell biology. Emphasis on membrane structure and function, organelle biogenesis, cell motility, the cytoskeleton, and extracellular matrix. Prerequisites: MBio 101.

370. Plant Molecular Biology (3)

Molecular aspects of photosynthesis; chloroplast biogenesis; plant gene expression; plant development; plant-microbe interactions; genetic engineering in plant systems. Prerequisite: MBio 345.

371. (Chm 371) Elements of Biochemistry I (3) fall

A general study of carbohydrates, proteins, lipids, nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry.

372. (Chm 372) Elements of Biochemistry II (3) spring

Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chm 371.

376. Classical & Molecular Embryology (3)

Differentiation of multicellular organisms from a single cell. Axis determination; gradients; induction and pattern formation viewed through modern analysis of regulated gene expression. Requisite: MBio 345 (previously or concurrently).

383. Molecular Biology Seminar (1)

Analysis of weekly colloquia in molecular biology. For senior biology and molecular biology majors. May be taken twice for credit.

387. Molecular Biology Honors Seminar (1)

Development, presentation and implementation of research proposals, and discussions of research. Required for senior biology and molecular biology majors pursuing departmental honors. Departmental permission required.

388. Molecular Biology Honors Seminar (1)

Continuation and extension of MBio 387. Departmental permission required.

391. Undergraduate Research (3)

Laboratory research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing; MBio 101, 102, 225; and a cumulative average of 3.0 in the major.

Graduate Study in Molecular Biology

The Department accepts a limited number of students who are interested in graduate study towards the doctor of philosophy degree in molecular biology.

Research thrusts include: microbial evolution and genetics; plant and animal molecular genetics; developmental genetics; eukaryotic cell biology; regulation of gene expression; and virology.

Each entering student is initially guided by his or her own faculty committee. A separate Ph.D. committee later directs

progress towards the advanced degree and tailors the program to fit special needs and interests of the student. Within the Ph.D. program there are three formal examinations, the qualifying exam, the general exam, and the dissertation defense.

Graduate Courses in Molecular Biology

405. Special Topics in Molecular Biology (3)

Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

406. Molecular Biological Seminar (1)

An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees. May be taken more than once for credit.

407. Molecular Biological Research (1-9)

Laboratory investigations in one of the department's research areas in molecular and cell biology.

408. Responsible Conduct of Science (0)

Responsible practice in research. Training in general laboratory methods; human subjects concerns; radiation safety; chemical hazards; aseptic technique; physics, mechanical, biological, and fire hazards; animal welfare. Occupational and workplace considerations. Recombinant DNA guidelines; patent and proprietary rights; controversies over applications of science. Appropriate aspects required of investigators in all departmental research projects.

411. Advanced Cell Biology (3)

Cell structure and biochemistry, as related to specialized cell functions.

419. Bacterial Genetics (3)

Structure and function of genetic information in prokaryotes. Composition, size, and organization of chromosomes and accessory elements; mechanisms of replication, recombination, transmission, and mutation; variation within and among strains.

421. Molecular Cell Biology I (3)

Molecular aspects of cell structure, cell motility, intracellular transport; and biomembrane dynamics. Prerequisite: MBio 411 or equivalent.

422. Molecular Cell Biology II (3)

Molecular aspects of gene expression, including genome structure and replication, RNA synthesis/processing, and protein synthesis. Prerequisite: MBio 345 or equivalent.

425. Male Reproductive Biology (2 or 3)

Molecular, cellular, and genetic aspects of the mammalian male reproductive system. Prerequisite: MBio 367 or equivalent.

427. Techniques in Cell and Molecular Biology (3)

Laboratory experiences in three or more cell and molecular biological techniques: gel electrophoresis of nucleic acids/proteins; polymerase chain reaction; DNA/RNA sequencing; molecular hybridization techniques; fluorescence microscopy; video enhanced microscopy; flow cytometry; electron microscopy tissue preparation; immunological detection methods; molecular cloning techniques; oocyte microinjection techniques; tissue culture methods; and autoradiography.

431. Advanced Topics in Cell Biology (3)

Current research problems in cell biology. May be repeated when a different topic is offered. Prerequisite: MBio 367 or equivalent.

432. Advanced Topics in Molecular Genetics (3)

Current research in molecular genetics. May be repeated when a different topic is offered. Prerequisite: MBio 345 or equivalent.

433. Advanced Topics in Developmental Biology (3)

Current research problems in developmental biology. May be repeated when a different topic is offered. Prerequisite: MBio 345 or equivalent.

463. Advances in Plant Molecular Biology (3)

Gene expression and molecular biology of plant systems. Biochemistry of photosynthesis and chloroplast development; higher plant developmental genetics; plant/microbe interactions; plant viruses; advances in genetic engineering in plants. Prerequisite: MBio 345 or equivalent.

464. Molecular Biology of Eukaryotic Organism (3)

Comparative analysis of several eukaryotes as model systems in cell biology, developmental biology, genetics, and molecular biology. Prerequisite: MBio 345 or equivalent.

468. Structure and Function of RNAs and Ribonucleoprotein Complexes (3)

Biochemistry and function of small nuclear RNPs, RNase P, ribosomes, self-splicing introns, signal recognition particle, RNA viruses. Functions of RNA in DNA replication, in regulation, as an enzyme, and as a repressor. Prerequisite: MBio 345 or equivalent.

Music

Professors. Paul Salerni, Ph.D. (Harvard); Steven Sametz, D.M.A. (Wisconsin).

Associate professors. Jerry T. Bidlack, M.F.A. (Boston U.); Nadine Sine, Ph.D. (N.Y.U.), *chairperson*.

Assistant Professor. Casey Teske, M.M., M.M.E. (New England Conservatory).

Adjunct professors. Nancy S. Bidlack, M.M. (Temple); Diane Ketchie, M.M. (Oberlin); Lawrence Wright, M.M. (Juilliard).

Instrumental instructors. Allison Herz, clarinet; Frank DiBussolo, electric guitar; Robin Kani, flute; Martin Webster, French horn; Richard Metzger, guitar; Louis Czechowski, jazz piano; Kim Heindel, organ; James Koch, percussion; Helen Beedle, piano; Debra Torok, piano; Mark Hulsebos, saxophone; Timothy Soberick, trombone; Lawrence Wright, trumpet; Scott Force, tuba; Rohan Smith, violin, viola; Nancy Bidlack, violoncello; John Absalom, voice; Margaret Cusack, voice; Diane Ketchie, voice.

Located in Lamberton Hall, the music department offers courses in music history, literature, theory, and composition, in addition to providing a wide range of performance experience in instrumental and vocal ensembles, and private instruction. Lamberton houses a listening library, practice rooms, a small collection of instruments, an electronic studio, a computer assisted ear-training facility, and a large concert and rehearsal room.

A student graduating with the music major will have gained a strong foundation in the basics of music theory and substantial exposure to the style and repertoire of western music from the Middle Ages to the present. This curriculum will prepare a student to continue graduate studies in musicology, music theory, or composition. A music major or minor taken in conjunction with a business major may lead to a variety of careers in arts management or in the recording and music publishing industries. Some students may find that a double major or a minor in music will provide the basis for a life-long involvement with an art form which does not necessarily generate income, but gives lasting enjoyment.

Major program. Students majoring in music must take a minimum of 31 credit hours (excluding Mus 80), to include thirteen hours in musicianship and theory (Mus 11, 12, 13, 15, 82, 243, 245), nine in music history (any three from Mus 233, 234, 235, 236), and three in performance courses (Mus 22-78). The remaining six credits for the major may be elected from department offerings and may include up to three additional performance courses.

Minor program. The minor requires a minimum of 17

credits and may include Mus 80 and 90. The program is designed to be flexible but must include Mus 11, one theory course (Mus 82 with Mus 12), one music history or literature course (Mus 80, 90, 130-132, 233-236), and two performance courses (Mus 22-78). The student may choose the remaining seven credits from department offerings, including up to four additional performance or musicianship courses.

Departmental Honors. A student must have a 3.5 average in courses in the major to pursue honors. Candidates for departmental honors should submit to the department chair a written proposal, prepared in consultation with a faculty project advisor, by the end of the junior year. The project could result in a research paper, a composition or a performance. Upon acceptance of the proposal by the department faculty, the student should register for Mus 350 for 4 to 6 credits, which may be taken all at once or over the senior year. The awarding of departmental honors will be contingent on the quality of the completed project.

Private lessons. A wide variety of instruments and voice lessons may be taken for one credit. They must be arranged through the department at set fees that are *not* included in tuition.

Performing groups. Admission to band, choir, ensembles, and orchestra is by audition, and students receive one credit per semester by registering for the appropriate course number. Although there is no limit to the number of courses in this series that may be taken, students should check with their advisor to determine the number that may be applied toward graduation (e.g. only eight credits are applicable in the College of Arts and Science).

Music at Lehigh. The department sponsors *Music at Lehigh*, a professional concert series of about ten performances a year open to students without charge. Recent appearances include the Orpheus Chamber Orchestra; Calliope, A Renaissance Band; and the Performer's Committee for Twentieth-Century Music. The Ralph N. Van Arnam Chamber Music Series, inaugurated in 1980, presents several concerts each year.

Course Offerings

Please note that many upper level courses have no prerequisites beyond Mus 11 or 80 and are open to anyone with basic knowledge of musical terminology. Students may test out of Mus 11 by examination.

11. Basic Musicianship (1) fall

Rudiments of musical notation, beginning skills in sightsinging, eartraining, rhythm and keyboard. Students may test out of this course by examination.

12. Musicianship I (1) spring

Continuation of Mus 11. Prerequisite: Mus 11 or equivalent.

13. Musicianship II (1) fall, even

Continuation of Mus 12, with emphasis on counterpoint. Prerequisite: Mus 12.

15. Musicianship III (1) fall, odd

Continuation of Mus 12, with emphasis on chromatic harmony. Prerequisite: Mus 12.

21-78. Applied music and performance courses may be repeated for graduation credit up to eight times. Prerequisite: consent of the chairperson or audition by faculty member responsible for the course.

21. Marching Band (1) fall**22. Wind Ensemble (1) spring****23. Concert Band (1) spring****24. Jazz Ensemble (1) fall-spring****25. Jazz Band (1) fall-spring****26. Wind Symphony (1) fall****31. University Choir (1) fall-spring****32. Choral Union (1) fall-spring****33. Overtones (1) fall-spring. Co-requisite: Mus 31****41. String Ensemble (1) fall-spring****42. Woodwind Ensemble (1) fall-spring****43. Brass Ensemble (1) fall-spring**

48. **Mixed Ensemble (1)** fall-spring
 51. **LUVME (1)** fall-spring
 52. **Percussion Ensemble (1)** fall-spring
 61. **String Orchestra (1)** fall-spring
 71. **Private Piano Study (1)** fall-spring
 72. **Private Vocal Study (1)** fall-spring
 73. **Private String Study (1)** fall-spring
 74. **Private Woodwind Study (1)** fall-spring
 75. **Private Brass Study (1)** fall-spring
 76. **Private Percussion Study (1)** fall-spring
 77. **Private Organ Study (1)** fall-spring
 78. **Other Private Study (1)** fall-spring

80. **Masterpieces of Music (3)** fall or spring
 Listening skills and awareness of musical styles in Western music developed through study of recognized masterpieces.

82. **Theory I: Harmony (3)** spring
 Exercises in writing in four-part chorale style. Must take in conjunction with or subsequent to Mus 12. Prerequisite: Mus 11 or equivalent. Teske

90. **Freshman Seminar (3)**

130. **Jazz (3)** spring
 The history of jazz from the beginning of the century until the present. Examination of the musical contributions of the leading figures in jazz—Joplin, Oliver, Armstrong, Morton, Henderson, Ellington, Basie, Parker, Gillespie, Davis, Coleman, Coltrane, etc. Emphasis on developing listening skills. Prerequisite: Mus 11 or 80 or equivalent. Salerno

131. **Major Genre (3)** fall or spring
 History and analysis of music of a particular type: Opera, oratorio, symphony, etc. May be repeated for credit as title varies. Prerequisite: Mus 11 or 80 or equivalent.

132. **Composer and Era (3)** fall or spring
 Life and development of a composer's style viewed in historical context. Title varies: Bach, Beethoven, Mozart, etc. May be repeated for credit as title varies. Prerequisite: Mus 11, or 80, or equivalent. Sine

233. **Medieval and Renaissance Music (3)** fall, odd
 Development of musical style from early Christian chant to the sacred and secular forms of the late sixteenth century, viewed in cultural contexts. Prerequisite: Mus 11 or 80 or equivalent. Sine

234. **Baroque and Classical Music (3)** spring, even
 The major genres and composers of the 17th and 18th centuries studied in their cultural context. Prerequisite: Mus 11 or 80 or equivalent. Sine

235. **Romantic Music (3)** fall, even
 Study of the major composers and their works from late Beethoven to Mahler and Strauss. Prerequisite: Mus 11 or 80 or equivalent. Sine

236. **Twentieth-Century Music (3)** spring, odd
 Beginning with the major trends at the turn of the century, a study of the important composers and works of our century to the present. Prerequisite: Mus 11 or 80 or equivalent. Sine

243. **Theory II: Counterpoint (3)** fall, even
 Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Must take Mus 13 concurrently. Prerequisite: Mus 82.

245. **Theory III: Form and Analysis (3)** fall, odd
 Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Must take Mus 15 concurrently. Prerequisite: Mus 82.

251. **Special Topics (1-3)**
 Study of musical topics in history or composition not covered in regular courses. May be repeated for credit, as title varies. Prerequisite: consent of the department chairperson.

253. **Composition I: Electronic and Acoustic Techniques (3)** fall

Writing for acoustic and electronic instruments based on twentieth-century models. Acoustic orchestration, simple recording techniques, analog and digital synthesis, effects processing. Use of the computer for score preparation and as a compositional tool. Prerequisite: Mus 82. Salerno

254. **Composition II (3)** spring
 Continuation of Mus 353. Prerequisite: 353.

291. **Independent Study (1-3)**
 Individually supervised work in history or composition, or continuation of projects begun in regular courses. May be repeated for credit. Prerequisite: consent of department chairperson.

300. **Apprentice Teaching (1-3)**

350. **Senior Project (4-6)**

Natural Science

Hayden N. Pritchard

This major program provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable extent in one area of science.

The program leads to a Bachelor of Arts degree and is designed especially for the following: 1. those students who want preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psychophysiology, medicine or dentistry, etc.); 2. those students who plan to teach in secondary schools or community colleges; and 3. those students without fixed career objectives who want undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) that must be approved by the dean of the College of Arts and science and the director of the program. The option may be chosen in chemistry, biology, geology, psychology, or in an approved interdisciplinary area (biophysics, marine science, biochemistry, computer science, etc.). Courses included in the option are worked out individually for the student by the major adviser.

Qualified students may be given permission at the end of the junior year to enter a program whereby they are able to begin work toward a graduate degree (master of arts, master of science, or master of education) during the senior year. Students enrolled in this program often complete all course requirements for the master's degree with one year of study beyond the bachelor's degree.

required preliminary courses

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Phy 11, 12	Introductory Physics I and Laboratory I (5)
Phy 21, 22	Introductory Physics II and Laboratory II (5) or
Phy 13, 14	General Physics and Laboratory (4)
Chm 21, 22	Introductory Chemical Principles and Laboratory (5)
Geol 21	Principles of Geology (3) or
Astr 1	The Solar System (3)
Biol 31, 32	Introduction to Environmental/Organismal Biology and Introduction to E/O Laboratory
Psyc 1	Introduction to Psychology (3)

required major courses

Chm 51, 52	Organic Chemistry (6) and
Chm 53, 58	Organic Chemistry Laboratory (2) or

Chm 31 Chemical Equilibria in Aqueous Systems (3) and
 Chm 187 Physical Chemistry I (3)
 Math elective (3)
 Option (24)
 Note: The mathematics elective and courses included in the option are taken with approval of the major adviser.
 Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors. Robert F. Barnes, Jr. Ph.D. (Berkeley); Mark H. Bickhard, Ph.D. (Chicago), *Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge*; Steven Louis Goldman, Ph.D. (Boston), *Andrew W. Mellon Distinguished Professor in the Humanities*; J. Ralph Lindgren, Ph.D. (Marquette); Clara H. Stewardson Professor of Philosophy; Norman P. Melchert, Ph.D. (Pennsylvania), *chairperson*, *Selfridge Professor of Philosophy*.
Associate professors. Gordon Bearn, Ph.D. (Yale); Robin S. Dillon, Ph.D. (Pittsburgh); Roslyn Weiss, Ph.D. (Columbia).

The study of philosophy does several things for a student. It improves certain skills, such as the ability to analyze and evaluate arguments, to identify faulty reasoning, to reason well, and to read and understand a difficult and complex text. It provides an acquaintance with the great works in philosophy which have helped form our culture. It teaches what our contemporaries are thinking, for example, about whether moral and aesthetic standards are objective, or when claims to have knowledge can be justified, or how the mind is related to the brain. It identifies important philosophical issues in areas of human activity such as medicine, business, religion, science and the law. Students of philosophy are studying the most important foundations of their view of themselves and their world.

The major program is substantial enough to prepare a student for subsequent graduate study. The program has the flexibility to supplement a major with coursework relevant to a variety of careers. Some of our majors have gone directly into banking, communications, insurance, marketing and publishing, immediately after graduation. Others, after graduate or professional school, go into academic philosophy, law, medicine, urban planning, and corporate management. There are also many courses of general interest to students from all four colleges.

The philosophy faculty emphasizes interaction with students. Students participate with faculty members in "reading parties" each spring—retreats where students and faculty read and discuss ideas together for a few days. They attend lectures by distinguished philosophers who visit the campus two to three times each semester and participate in discussions with students. They join the Philosophy Club which brings students and faculty together in small group activity once a week.

Department honors are awarded on the basis of a thesis or a disputation (a public defense of a philosophical thesis or theses) supervised by one or more members of the department, and the attainment of a cumulative average for all courses in philosophy of 3.25 or better at the time of graduation.

The Minor Program

The minor in philosophy consists of eighteen credit hours of course work. The courses will include Phil. 131 and at least one course at the 200-level. Minor programs may be either of a general character or organized around a special theme such as: the philosophy of science, logic, ethics and value theory, the history of philosophy, and social philosophy.

The Major Program

The major in philosophy consists of thirty credit hours of course work. The specific courses to be taken are decided

jointly by the student and the departmental adviser. All major programs include the following:

Phil 114	Foundations of Logic (3)
Phil 131	Ancient Philosophy (3)
Phil 135	Modern Philosophy (3)
Phil 291	Seminar (3)

One of the following:

Phil 105	Ethics (3)
Phil 205	Contemporary Ethics (3)

Plus one of the following:

Phil 128	Philosophy of Science (3)
Phil 220	Knowledge and Justification (3)
Phil 228	Topics in the Philosophy of Science (3)

All major programs must include at least three courses numbered 200 and above (not including Phil 301) and no more than three courses numbered 100 and below. At the discretion of the department, a major may be required to take and pass English 171, Practical Writing.

Undergraduate Courses

1. The Great Conversation I (3)

Development of thought about philosophical issues concerning knowing, human excellence, reality, God, and the soul. Pre-Socratics to medieval thinkers; Socrates, Plato, Aristotle and Augustine.

2. The Great Conversation II (3)

Development of philosophical thought in modern times, from Descartes, Hume, and Kant to contemporary pragmatism, existentialism, and analytic philosophy of Reality; human nature; morality and God in the era of modern science. May be taken independently of Phil 1.

10. Introduction to Philosophy (3) fall

Basic philosophical questions, perennial and contemporary, such as the objectivity of morals, the justification of government, the place of mind and feeling in the world of matter and energy, the nature of knowledge and truth, and the reality of God.

105. Ethics (3)

Examination of right and wrong, good and bad, from classic sources such as Plato, Aristotle, Hume, Kant, Mill and Nietzsche.

113. Practical Logic

The role of logic in problem solving and decision-making processes. Comparison of deductive and inductive reasoning and justification. Practice in analysis, criticism, evaluation and construction of arguments. Emphasis on material drawn from real-life contexts.

114. Fundamentals of Logic

Symbolic languages as theoretical models of logical features of English discourse, such as necessary truth and valid inference. Construction of logical proofs.

115. Business Ethics (3)

Special problems in moral responsibility and ethical theory relating to contemporary business institutions, due to new dimensions of knowledge and evaluation, and emerging techniques of decision-making, planning, and management that characterize those institutions.

116. Medical Ethics (3)

Contemporary moral problems encountered in the practice of medicine examined in the light of ethical theories of the nature and foundation of rights and moral obligations. Abortion, euthanasia, genetic engineering, the nature of informed consent, the distribution of health care, etc.

117. Engineering Ethics

Ethical issues and problems encountered in the practice of engineering, examined in light of major ethical theories.

Case study approach that emphasizes issues such as responsibility for safety; obligations to employers, peers, and the public; professionalism; whistleblowing; codes of ethics.

122. Philosophy of Law (3)

Analysis of the conceptual foundations of our legal system. Special attention is devoted to the nature of law and legal obligation, liberty and privacy in constitutional litigation, justice and contractual obligation, theories of punishment in criminal law, and the nature and scope of responsibility in criminal law. Lindgren

123. Aesthetics (3)

Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. Bearn

126. Feminism and Philosophy

Analysis of the nature, sources and consequences of the oppression and exploitation of women, and justification of strategies for liberation. Topics include women's nature and human nature, sex roles and gender differences, sexism, femininity, sexuality, reproduction, mothering. Dillon

128. Philosophy of Science (3)

Introduction to the structure and methods of scientific investigation. The nature of explanation, confirmation, and falsification. Scientific progress: What is it? Would it be suffocated by obedience to completely rational methods? Bearn

131. (Clss 131) Ancient Philosophy (3)

Historical study of philosophy in the classical world. The origins of the Western tradition in philosophy and science with the Presocratics; Socrates, Plato (including *Republic*) and Aristotle (including parts of *Nicomachean Ethics*). Weiss

133. Medieval Philosophy (3)

Historical study of philosophy from the Roman Empire to the Renaissance. Attention to Islamic, Jewish, and Christian traditions and their interaction with the scientific and cultural life of the period. Goldman

135. Modern Philosophy (3)

Philosophers from the Renaissance through the end of the 19th century: Descartes, Locke, Hume, Rousseau, Kant and Hegel.

139. Contemporary Philosophy (3)

Philosophical thought from the late-19th century to the present; pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgment, meaning, the place of the individual in the physical world and society, and the impact of scientific method upon all of these.

181. (Rel 181) Reason and Religious Experience (3)

A critical look at some of the fundamental problems of religion: the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth.

205. Contemporary Ethics

Examination of significant questions addressed by contemporary moral philosophers. Topics vary, but might include: What is a good person? Can a woman be good in the same way as a man? Is morality relative or absolute? Is morality all that important? Prerequisite: Phil. 105 or consent of the chairperson. Dillon

214. Logical Theory (3)

Conceptual foundations and philosophical significance of logical theories. Syntactic and semantic methods in logic, and their interrelations. Philosophical impact of important technical results, including Goedel's incompleteness theorem. Some discussion of alternative logics. Prerequisite: Phil 114 or consent of the department chairperson. Barnes

220. Knowledge and Justification (3)

Recent work in epistemology. Questions addressed include: If you can't know whether you are dreaming, how can you know you have two hands? Does knowledge require answers to all possible doubts or only all reasonable doubts? How should we determine the horizon of the reasonable—psychologically or philosophically? Bearn

221. (Law 221) Sex Discrimination and the Law (3)

A critical study of the law of sex-discrimination in areas of constitutional law, labor law, education law, family law and criminal law. A case approach that covers such topics as equal protection, equal educational and employment opportunity, reproductive rights, sexual violence and affirmative action. Lindgren

224. (Rel 224) Topics in the Philosophy of Religion (3)

Selected problems and issues in the philosophy of religion. May be repeated for credit as the subject matter varies. Prerequisite: Phil 124 or consent of the department chairperson.

228. Topics in the Philosophy of Science (3)

Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Prerequisite: Phil 128 or consent of the department chairperson. Goldman

237. (Rel 237) Kierkegaard and Nietzsche (3)

Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence. Melchert

239. Heidegger and Wittgenstein

Two influential philosophers of the 20th Century. Heidegger is among the founders of Existentialism and Wittgenstein of Ordinary Language Philosophy. They are both concerned to understand the place of humans on the earth as more intimate than that of an intellect in space. The Late Romantic attempt to recover the ordinary. Bearn

250. The Minds of Men and Robots (3)

Is the nature of thinking illuminated by what computers can do? Is the brain just a complex computer? Could a robot feel pain? Be angry? Recent work in artificial intelligence, psychology, and philosophy.

251. Action, Free Will, and Fate (3)

Are we free to act as we choose? Are we free to choose? The concept of action: intentions and actions, reasons and causes, and whether there can be deterministic explanations of actions. Prerequisite: one previous course in philosophy (except 113, 221). Melchert

271. Readings in Philosophy (1-3)

A course in readings designed primarily for the undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

272. Readings in Philosophy (1-3)

A course of readings designed primarily for undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

291. Seminar (3)

Examination of selected topics for philosophy majors and minors and other advanced students. May be repeated for credit.

301. Participative Philosophy (1)

Participation in at least one Department Reading Party, plus attendance at a minimum of six approved lectures by visiting scholars, with a two page written on each.

Physics

Professors. Arnold H. Kritz, Ph.D. (Yale), *chairperson*; Garold J. Borse, Ph.D. (Virginia), *associate chairperson*; Gary G. DeLeo, Ph.D. (Connecticut); Robert T. Folk, Ph.D. (Lehigh); W. Beall Fowler, Ph.D. (Rochester); James D. Gunton, Ph.D. (Stanford), *Dean of the College of Arts and Science*; Alvin S. Kanofsky, Ph.D. (Pennsylvania); Yong W. Kim, Ph.D. (Michigan); Sheldon H. Radin, Ph.D. (Yale); Wesley R. Smith, Ph.D. (Princeton); Michael Stavola, Ph.D. (Rochester); George D. Watkins, Ph.D. (Harvard), *Sherman Fairchild Professor of Solid-State Studies*.

Associate professors. Brent W. Benson, Ph.D. (Penn State); John P. Huennekens, Ph.D. (Colorado); Jerome C. Licini, Ph.D. (M.I.T.); Russell A. Shaffer, Ph.D. (Johns Hopkins); Jean Toulouse, Ph.D. (Columbia).

Assistant professors. Daniel C. Hong, Ph.D. (Boston Univ.); Michelle S. Malcuit, Ph.D. (Rochester); H. C. Daniel Ou-Yang, Ph.D. (U.C.L.A.); Alan D. Streater, Ph.D. (Colorado).

Lehigh offers four undergraduate degrees in physics: the Bachelor of Science in Physics and the Bachelor of Arts in Physics in the College of Arts and Sciences, and the Bachelor of Engineering Physics and the five year program for the Bachelor of Science in Electrical Engineering and Engineering Physics in the College of Engineering and Applied Science.

(The B.S. in E.E.E.P. is described on p. 35).

The two bachelor of science curricula require somewhat more physics and mathematics than the bachelor of arts major, while the latter requires more courses in the humanities and social sciences. By proper choice of electives, any of these programs can prepare a student for graduate work in physics or the physical aspects of other sciences or engineering disciplines or for technical careers requiring a basic knowledge of physics. The bachelor of arts curriculum is particularly useful for those planning careers in areas where knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.

A comparison of the three curricula in terms of credit hours in various broad categories is given below.

	Engineering College	College of Arts and Science	
	B.S.E.P.	B.S.	B.A.
Freshman English	6	6	6
Distribution Courses*	19	19	22
Required preliminary and major courses	68	68	60
Approved Electives	14	14	11
Electives	20	19	22
Total	127	126	121

*Not including mathematics or science

Physics students study the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The student also studies applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic, and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills that can be applied in the experimental search for new knowledge or in applications of the known theories.

A majority of physics graduates go to graduate school in physics, often earning the Ph.D. degree. These people take university or college faculty positions, or work on research in a variety of university, government, or industrial laboratories.

Some students choose employment immediately after the bachelor's degree. They use their many approved and free electives to supplement their science background with applied courses, such as engineering, to develop the skills needed for a position in a particular area. For example, by combining various electrical engineering courses with physics courses in electronics and solid-state physics, a strong applied background can be developed for employment in solid-state electronics. If the student chooses applied mathematics courses and computer courses to supplement the physics courses, a strong preparation can be achieved for employment in the many areas that use numerical methods in analysis and development.

Many other specialties may be developed by the student by appropriate use of electives so that the bachelor-degree student can offer an employer the advantages of a broad and fundamental science background combined with a significant concentration in a particular area of science, engineering, or applied mathematics.

Because of the fundamental role of physics in all the natural sciences, students also use the physics major as an excellent preparation for graduate study in many other scientific areas, such as applied mathematics, computer science, biophysics, molecular biology, astrophysics, geology and geophysics, material and engineering, meteorology, or physical oceanography. Attractive engineering areas with a high science content include aeronautical engineering; nuclear engineering, including both fission and fusion devices; electrical engineering, including instrumentation, electronics, and solid-state devices, electrical discharges and other plasma-related areas; and mechanical engineering and mechanics, including fluids and continuum mechanics.

The broad scientific background developed in the physics curriculum is also an excellent background for professional schools, such as law (particularly patent law), medicine, and optometry.

The recommended sequences of courses for the three degrees are:

B.A. (A. & S. Coll.)	B.S. (A. & S. Coll.)	B.S.E.P. (Engr. Coll.)
Freshman Year		
FALL Semester		
Frshmen English (3)	Frshmen English (3)	Frshmen English (3)
Phy 11 (Lec) (4)	Phy 11 (Lec) (4)	Phy 11 (Lec) (4)
Phy 12 (Lab) (1)	Phy 12 (Lab) (1)	Phy 12 (Lab) (1)
Math 21 (4)	Math 21 (4)	Math 21 (4)
Col. Seminar (3)	Col. Seminar (3)	HSS (3)
A+S I (1)	A+S I (1)	
[16]	[16]	[15]
SPRING Semester		
Frshmen English (3)	Frshmen English (3)	Frshmen English (3)
Chm 21 (Lec) (4)	Chm 21 (Lec) (4)	Chm 21 (Lec) (4)
Chm 22 (Lab) (1)	Chm 22 (Lab) (1)	Chm 22 (Lab) (1)
Math 22 (4)	Math 22 (4)	Math 22 (4)
Dist. Req. (3)	*Engr I (3)	Engr I (3)
[15]	[15]	[15]
Sophomore Year		
FALL Semester		
Phy 21 (Lec) (4)	Phy 21 (Lec) (4)	Phy 21 (Lec) (4)
Phy 22 (Lab) (1)	Phy 22 (Lab) (1)	Phy 22 (Lab) (1)
Math 23 (4)	Math 23 (4)	Math 23 (4)
Dist. Req. (6)	Dist. Req. (6)	Eco 11 or 12 (3)
[15]	[15]	Elective (3)
SPRING Semester		
Phy 31 (3)	Phy 31 (3)	Phy 31 (3)
Phy 190 (3)	Phy 190 (3)	Phy 190 (3)
Math 205 (3)	Math 205 (3)	Math 205 (3)
Dist. Req. (6)	Dist. Req. (3)	HSS (3)
	Electives (4)	Elective (3)
[15]	[16]	[15]

Junior Year

FALL Semester

Phy 212	(3)	Phy 212	(3)	Phy 212	(3)
Phy 215	(3)	Phy 215	(3)	Phy 215	(3)
Phy 260**	(0-2)	Phy 260	(2)	Phy 260	(2)
Math 322	(3)	Math 322	(3)	Math 322	(3)
Dist. Req.	(3)	Dist. Req.	(3)	Electives	(6)
Elective	(3)	Elective	(3)		
[15-17]		[17]		[17]	

SPRING Semester

Phy 213	(3)	Phy 213	(3)	Phy 213	(3)
Phy 261**	(2-0)	Phy 261	(2)	Phy 261	(2)
Phy 362	(3)	Phy 362	(3)	Phy 362	(3)
Phy 264	(3)	Phy 264	(3)	Phy 264	(3)
Electives	(5)	Dist. Req.	(3)	HSS	(3)
		Elective	(3)	Elective	(3)
[16-14]		[17]		[17]	

Senior Year

FALL Semester

Phy 340	(3)	Phy 340	(3)	Phy 340	(3)
Electives	(6)	Phy 216	(3)	Phy 216	(3)
Appr. Elec.	(5)	Dist. Req.	(3)	HSS	(3)
		Electives	(6)	Electives	(8)
[14]		[15]		[17]	

SPRING Semester

Phy 171	(1)	Phy 171	(1)	Phy 171	(1)
Appr. Elec.	(6)	Electives	(14)	HSS	(3)
Electives	(8)			Electives	(11)
[15]		[15]		[15]	
[121]		[126]		[126]	

*or an equivalent course in scientific computing

**only one of the two lab courses (PH 260/1) is required for the B.A.

The electives include at least fourteen credit hours for Bachelor of Science degrees and eleven credit hours for the Bachelor of Arts degree of approved technical electives. Included in this group must be two of the following courses: Phys 363, 369, (352 or 355), and (348 or 365). Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives. Up to 6 credit hours of the following courses may be included as part of the credit hours required for graduation: Aerospace Studies, Jour 1-10, Military Science, and Mus 21-78.

Research opportunities. A majority of physics and engineering physics majors take advantage of opportunities to participate in research under the direction of a faculty member. Research areas available to undergraduates are the same as those available to graduate students; they are described below under the heading For Graduate Students. Undergraduate student research is arranged informally as early as the sophomore (or, occasionally, freshman) year at the initiation of the student or formally as a senior research project. In addition, a number of students receive financial support to do research during the summer between their junior and senior years, either as Physics Department Summer Research Participants or as Sherman Fairchild Scholars.

The use of electives. The electives provided in each of the physics curricula provide the student with an opportunity to develop special interests and to prepare for graduate work in various allied areas. In particular, the many available upper-level physics, mathematics, and engineering courses can be used by students in consultation with their faculty advisors to structure programs with special emphasis in a variety of areas such as solid-state electronics or biophysics.

Departmental Honors. Students may earn departmental honors by satisfying the following requirements:

Grade point average of at least 3.50 in physics courses.

Satisfactorily completing the following courses (these may be included in the list of approved electives): Phy 369; two of Phy 348, 363 and (352 or 355); one 400-level physics course.

Six credits Phy 273 (Research) plus submission of a written report and an oral presentation open to faculty and students.

Undergraduate Courses in Physics

9. Introductory Heat and Thermodynamics (1)

Temperature, heat, and the laws of thermodynamics; kinetic theory of gases. The student will be scheduled for the appropriate part of Phys 11. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the mechanics part of Phys 11, and consent of the chairperson of the department.

11. Introductory Physics I (4)

Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: Math 21, 31 or 41, previously or concurrently. DeLeo or Boise

12. Introductory Physics Laboratory I (1)

A laboratory course taken concurrently with Phys 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week. Prerequisite: Phys 11, preferably concurrently. Radin

13. General Physics (3)

A continuation of Phys 11, primarily for students in the College of Arts and Science and premedical students. Electrostatics, electromagnetism, light, atomic physics, nuclear physics and radioactivity. Prerequisites: Phys 11 and Math 21, 31 or 41. Radin

14. General Physics Laboratory (1)

A laboratory course to be taken concurrently with Phys 13. Prerequisite: Phys 12; Phys 13, preferably concurrently. Folk

19. Introductory Optics and Modern Physics (1)

Physical and geometrical optics; introduction to modern physics. The student will be scheduled for the appropriate part of Phys 21. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the electricity and magnetism part of Phys 21, and consent of the chairperson of the department.

21. Introductory Physics II (4)

A continuation of Phys 11. Electrostatics and magnetostatics; DC circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisite: Phys 11; Math 23, 32, or 44, previously or concurrently. Folk or Shaffer

22. Introductory Physics Laboratory II (1)

A laboratory course to be taken concurrently with Phys 21. One three-hour laboratory period per week. Prerequisite: Phys 12; Phys 21, preferably concurrently. Folk

31. Introduction to Quantum Mechanics (3)

Experimental basis and historical development of quantum mechanics; the Schrodinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisite: Phy 13 or 21; Math 205, previously or concurrently. Benson, Stavola

42. Concepts in Physics (3)

The principal concepts and discoveries of physics are presented in a concise manner. The purpose of the course is to provide students majoring in subjects other than science and engineering with sufficient background to enable them to appreciate physics and its impact on modern society. The laboratory serves to demonstrate the concepts covered in class and to provide some exposure to modern measurement devices and computers. High school physics is not assumed. Two recitations and one laboratory per week. No prerequisite. DeLeo

91. Measurement and Transducers (1)

Computer-assisted laboratory course, dealing with physical

phenomena in mechanics, electricity and magnetism, optics, spectroscopy and thermodynamics. Measurement strategies are developed and transducers devised. Computer simulation, analysis software, digital data acquisition. Prerequisites: Phys. 21 and 22 or their equivalent or consent of chairperson. Kim

171. Physics Proseminar (1)

Discussion of current problems in physics. Intended for seniors majoring in the field.

190. Electronics (3)

DC and AC circuits, diodes, transistors, operational amplifiers, oscillators, and digital circuitry. Two laboratories and one recitation per week. Prerequisites: Phy 21 and 22, or Phy 13 and 14. Smith

For Advanced Undergraduates And Graduate Students

212. Electricity and Magnetism I (3)

Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys 21 or 13; Math 205, previously or concurrently. Huennekens

213. Electricity and Magnetism II (3)

Maxwell's equations, Poynting's theorem, potentials, the wave equation, waves in vacuum and in materials, transmission and reflection at boundaries, guided waves, dispersion, electromagnetic field of moving charges, radiation, Lorentz invariance and other symmetries of Maxwell's equations. Prerequisite: Phys 212. Licini

215. Classical Mechanics I (3)

Kinematics and dynamics of point masses; force laws, including motion in a central force field, simple harmonic motion and non-linear oscillations; conservation laws; description of a system of particles, including collisions; moving coordinate systems and the special theory of relativity. Prerequisites: Phys 21 or Phys 13 and Math 205, previously or concurrently. Kritz

216. Classical Mechanics II (3)

Continuation of Phys 215. Gravitation; rotating coordinate systems; motions of rigid bodies; Lagrange's and Hamilton's equations; continuum mechanics, including elasticity and fluid mechanics. Prerequisite: Phys 215. Smith

260. Laboratory Techniques (2)

Laboratory practice, including machine shop, vacuum systems, electronic instrumentation, computers and integrated circuits, high-voltage measurements, counting and statistics. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Kanofsky

261. Optics, Spectroscopy, and Quantum Physics Laboratory (2)

Experiments in geometrical optics, interference and diffraction, spectroscopy, lasers, and quantum phenomena. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Streater

264. Nuclear and Elementary Particle Physics (3)

Models, properties, and classification of nuclei and elementary particles; nuclear and elementary particle reactions and decays; radiation and particle detectors; accelerators; applications. Prerequisites: Phys 31 and Math 205. Kanofsky

273. Research (2-3)

Participation in current research projects being carried out within the department. Intended for seniors majoring in the field. May be repeated once for credit.

281. Basic Physics I (3)

A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on

their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics.

282. Basic Physics II (3)

Continuation of Phys 281.

312. Advanced Laboratory (1) fall-spring

Experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Prerequisite: senior or graduate standing in the field, or consent of the department chairperson. May be repeated for credit.

332. (Astr 332) High-Energy Astrophysics (3)

Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

340. Thermal Physics (3) fall

Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on applications to classical and quantum mechanical physical systems. Prerequisites: Phys 13 or 21, and Math 23, 32 or 44. Stavola

342. (Astr 342) Relativity and Cosmology (3)

Special and general relativity. Schwarzschild and Kerr black holes. Super massive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

348. Plasma Physics (3)

Single particle behavior in electric and magnetic fields, plasmas as fluids, waves in plasmas, transport properties, kinetic theory of plasmas, controlled thermonuclear fusion devices. Prerequisites: Phys 21, Math 205, and senior standing or consent of the chairman of the department. Kritz

352. Modern Optics (3)

Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 205, and Phys 212 or ECE 202. Malcuit

355. Lasers and Non-linear Optics (3)

Basic principles and selected applications of lasers and non-linear optics. Topics include electromagnetic theory of optical beams, optical resonators, laser oscillation, non-linear interaction of radiation with atomic systems, electro- and acousto-optics, optical noise, optical waveguides, and laser devices. Prerequisites: Phys 31; Phys 213 or ECE 203, previously or concurrently. Malcuit

362. Atomic and Molecular Structure (3)

Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms, Pauli principle, Zeeman and Stark effects, hyperfine structure, structure and spectra of simple molecules. Prerequisite: Phys 31 or Chm 341. Huennekens

363. Physics of Solids (3)

Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: Phys 31 or Mat 316 or Chm 341. Benson, Toulouse

365. Physics of Fluids (3)

Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phys 212 or ECE 202, and Phys 340 or ME 104 or equivalent, previously or concurrently. Smith

369. Quantum Mechanics I (3)

Principles of quantum mechanics: Schroedinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: Phys 31, Math 205; Phys 216, previously or concurrently. Fowler

372. Special Topics in Physics (1-3)

Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences.

382. Applied Solid State Physics (3)

Applications of fundamental solid state physics to topics of current interest with emphasis on various physical effects and their use in practical applications. Topics include: effects of barriers and applied potentials on band structure (semiconductor junctions and interfaces), luminescence and photon absorption (solid-state lasers and radiation detectors), ferroelectricity and dielectric phenomena (electro-optical communication), superconductivity (Josephson and quantum interference devices). Prerequisite: Phys 363, or consent of the chairman of the department. Stavola

For Graduate Students

The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:

Solid-state physics (experimental). Optical and electronic properties of defects in semiconductors and insulators, electron paramagnetic resonance, ultrasonic attenuation, Raman spectroscopy, luminescence spectroscopy. Properties of thin films, physics of semiconductor devices. Colloidal suspensions and complex fluids.

Solid-state physics (theoretical). Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.

Atomic and molecular physics. Electron attachment. Optically assisted reactions. Collisional phenomena in alkali metal vapors.

Plasma Physics (Theoretical). Studies of heating, current drive, transport, and plasma diagnostics by transient synchrotron radiation in magnetically confined toroidal plasmas. The research is closely related to ongoing and proposed experiments at major fusion laboratories.

Plasma spectroscopy. Collisional and collisionless phenomena of very dense plasmas. Laser-produced plasmas.

Nuclear theory. The few nucleon problem, nuclear structure theory.

Physics of fluids. Microscopic fluctuations in a flow. Shock-induced reactions in gases and phase transitions at liquid-vapor interfaces. Small particle dynamics. Light-scattering spectroscopy.

Statistical physics (experimental). Non-equilibrium fluctuations in gases. Chaotic transitions. Colloidal suspensions and complex fluids. Disordered materials.

Statistical physics (theoretical). Kinetic theory, statistical basis of hydrodynamics, non-linear processes, bound states and internal degrees of freedom in kinetic theory. Study of pattern formation in dendritic growth.

Elementary particles (experimental). Fermilab and Brookhaven are used in channeling, device development, and particle jet studies.

Elementary particles (theoretical). Properties of leptons and vector bosons, weak and electromagnetic interactions. Quark-Glauber calculations of elastic and inelastic scattering.

Non-linear optics. Theoretical and experimental work in lasers and non-linear optics.

Van de Graaff studies. Experiments to study nuclear reactions, channeling, new instrumentation techniques, Rutherford back-scattering using the Lehigh van de Graaff accelerator.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor's degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

Doctoral candidates may be required by their thesis committee to demonstrate a reading knowledge of one language, usually chosen from French, German or Russian.

Certain advanced courses in other fields, notably mechanics, metallurgy and materials engineering, electrical engineering, and chemistry, may be included in a graduate program. Further details regarding the special requirements for degrees in physics may be obtained on application to the department chairperson.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Facilities for Research. The 1985-86 renovation and addition to the Physics Building has made available many new research laboratories and improved the quality of the older research space. It also expanded the shop area and provided a direct connection to the Sherman Fairchild Laboratory, where solid-state physics faculty and research space are located.

Among the research equipment available in the various experimental physics laboratories are: three electron spin resonance laboratories; a laboratory for optical detection of magnetic resonance; facilities for optical absorption and luminescence studies; ultraviolet, visible, and infrared spectrophotometers; liquid nitrogen, hydrogen, and helium cryogenic equipment; several shock tubes; film scanning apparatus; cosmic ray detectors; 9 high-power lasers (4 argon-ion lasers, 2 tunable pulsed dye lasers, a ruby laser, and 2 mode-locked, Q-switched Nd-glass lasers); crystal-growing facilities; a mass-spectrometer, large interferometers, an electron microscope, a high-density plasma source; electronic instrumentation for data acquisition and analysis, including several minicomputers, many microcomputers, and signal averagers.

A 3 MeV Van de Graaff accelerator housed in the Sherman Fairchild Laboratory is used to study radiation defects in solids, to analyze impurity distributions in thin films, to develop instrumentation, and to study channeling and nuclear physics. Also available in materials and electrical engineering laboratories in the Fairchild Laboratory are excellent facilities for the preparation of solid-state materials and the fabrication of solid-state devices; these facilities are heavily used by physics students doing experimental solid-state research.

Graduate Courses in Physics**411. Survey of Nuclear and Elementary Particle Physics (3)**

Intended for non-specialists. Fundamentals and modern advanced topics in Nuclear and Elementary Particle Physics. Topics include: nuclear force, structure of nuclei, nuclear models and reactions, scattering, elementary particle classification, SU(3), quarks, gluons, quark flavor and color, leptons, gauge theories, GUT, the big bang. Prerequisite: Phys 369. Shaffer

420. Mechanics (3)

Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory. Streater

421. Electricity & Magnetism I (3)

Electrostatics, magnetostatics, Maxwell's equations, dynamics of charged particles, multipole fields. Kim

422. Electricity & Magnetism II (3)

Electrodynamics, electromagnetic radiation, physical optics, electrodynamics in anisotropic media. Special theory of relativity. Prerequisite: Phys 421. Licini

424. Quantum Mechanics II (3)

General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys 369 or equivalent. Toulouse

425. Quantum Mechanics III (3)

A continuation of Phys 424. Relativistic quantum theory of the electron; theory of radiation. Shaffer

428. Methods of Mathematical Physics I (3)

Analytical and numerical methods of solving the ordinary and partial differential equations that occur in physics and engineering. Includes treatments of complex variables, special functions, product solutions and integral transforms. Folk

429. Methods of Mathematical Physics II (3)

Continuation of Physics 428 to include the use of integral equations. Green's functions, group theory, and more on numerical methods. Prerequisite: Phys 428. Folk

431. Theory of Solids (3)

Advanced topics in the theory of the electronic structure of solids. Many-electron theory. Theory of transport phenomena. Magnetic properties, optical properties. Superconductivity. Point imperfections. Prerequisite: Phys 363 and Phys 424. Fowler

442. Statistical Mechanics (3)

General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisite: Phys 340 and 369. Kim

443. Nonequilibrium Statistical Mechanics (3)

A continuation of Phys 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; nonequilibrium thermodynamics. Prerequisite: Phys 442. Hong

446. Atomic and Molecular Physics (3)

Advanced topics in the experimental and theoretical study of atomic and molecular structure. Topics include fine and hyperfine structure, Zeeman effect, interaction of light with matter, multi-electron atoms, molecular spectroscopy, spectral line broadening atom-atom and electron-atom collisions and modern experimental techniques. Prerequisite: Phys 424 or consent of the department. Huennekens

455. Physics of Nonlinear Phenomena (3)

Basic concepts, theoretical methods of analysis and experimental development in nonlinear phenomena and chaos. Topics include nonlinear dynamics, including period-multiplying routes to chaos and strange attractors, fractal geometry and devil's staircase. Examples of both dissipative and conservative systems will be drawn from fluid flows, plasmas, nonlinear optics, mechanics and waves in disordered media. Prerequisites: graduate standing in science or engineering, or consent of the chairman of the department. Kim

462. Theories of Elementary Particle Interactions (3)

Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Phys 425. Shaffer

465. Nuclear and Elementary Particle Physics (3)

Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

467. Nuclear Theory (3)

Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

471. (Mech 411) Continuum Mechanics (3)

An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of theories to specific problems are given. G. Smith

472. Special Topics in Physics (1-3)

Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

474. Seminar in Modern Physics (3)

Discussion of important advances in experimental physics.

May be repeated for credit when a different topic is offered.

475. Seminar in Modern Physics (3)

Discussion of important advances in theoretical physics. May be repeated for credit when a different topic is offered.

491. Research (3)

Research problems in experimental or theoretical physics.

492. Research (3)

Continuation of Phys 491. May be repeated for credit.

Psychology

Professors. Mark H. Bickhard, Ph.D. (Chicago), *Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge*; Arthur L. Brody, Ph.D. (Indiana); Donald T. Campbell, Ph.D. (Berkeley), *University Professor of Sociology and Anthropology and Psychology*; David L. Cundall, Ph.D. (Arkansas); Murray Itzkowitz, Ph.D. (Maryland); Martin L. Richter, Ph.D. (Indiana); George K. Shortess, Ph.D. (Brown); Neal G. Simon, Ph.D. (Rutgers); John G. Nyby, Ph.D. (Texas, Austin), *chairperson*.

Associate professors. Diane T. Hyland, Ph.D. (Syracuse); Barbara C. Malt, Ph.D. (Stanford); William Newman, Ph.D. (Stanford); S. Lloyd Williams, Ph.D. (Stanford).

Assistant professors. Susan Barrett, Ph.D. (Brown); Padraig O'Seaghdha, Ph.D. (Toronto); Roger D. Phillips, Ph.D. (Rochester); Jill E. Schneider, Ph.D. (Wesleyan); Elissa D. Wurf, Ph.D. (Michigan).

Adjunct professors. Ian Birky, Ph.D. (Oklahoma State); Roy C. Herrenkohl, Ph.D. (N.Y.U.); Edwin J. Kay, Ph.D. (Lehigh); Theophile Krawiec, Ph.D. (N.Y.U.); Judith N. Lasker, Ph.D. (Harvard); John F. Riley, Ed.D. (Lehigh); Robert E. Rosenwein, Ph.D. (Michigan); Edward S. Shapiro, Ph.D. (Pittsburgh).

Major Program in Psychology

The bachelor of arts in psychology is a social science major requiring a minimum of 35 credit hours in psychology as defined below. Second-semester freshmen who have completed Psyc 1 can enroll in the 100-level courses by petition, and should check with the chairperson of the psychology department if interested.

Required Major Courses

Psyc 1	Introduction to Psychology (4) and
Psyc 110	Experimental Design and Statistical Analysis (3)
Psyc 210	Experimental Psychology (4)

Plus the following

one from each of the four categories

A) Psyc 107	Child Development (3)
Psyc 108	Adolescent Development (3)
Psyc 109	Adulthood and Aging (3)
B) Psyc 21	Social Psychology (3)
Psyc 153	Personality (3)
C) Psyc 117	Cognitive Psychology (3)
Psyc 171	Learning (3)
D) Psyc 176	Cognitive Neuroscience (3)
Psyc 177	Introduction to Behavioral Neuroscience (3)

and at least four 300-level Psychology courses, excluding Psyc 393 (Research), Psyc 300 (Apprentice teaching), and Psyc 395, 396 (Thesis).

Additional Required Courses. All students must also fulfill College of Arts and Science distribution requirements, and successfully complete at least 121 credit hours for graduation.

Recommended Electives

The bachelor of arts program in psychology is a flexible preparation for a number of fields. With a suitable selection of additional courses, students can prepare themselves for graduate study in clinical psychology, developmental psychology, social psychology, personality, or for careers in areas for which psychology is a desirable and relevant major, e.g., law, social work, nursing, or special education. Courses recommended, in addition to those major courses listed above are:

Psyc 161	Supervised Research (1-3)
Psyc 393	Independent Research (1-3)
Psyc 162	Psychological Field Work (1-3)
Psyc 395, 396	Thesis (6)
Psyc 421, 422	Analysis and Design of Experiments (6) (by petition)
Math 41	BMSS Calculus I (3)
EES 31	Intro. Env. & Org. Biology (3)
MBio 33	Intro Cell & Molecular Biology (3)
MBio 101	Genetics (3)

With greater emphasis on mathematics and science, the program provides preparation for graduate study in experimental psychology, medicine or dentistry. In this case, additional recommended courses are:

Psyc 161	Supervised Research (1-3)
Psyc 393	Independent Research (1-3)
Psyc 162	Psychological Field Work (1-3)
Psyc 374	Sensation and Perception Laboratory (1)
Psyc 395, 396	Thesis (6)
Psyc 421, 422	Analysis and Design of Experiments (6) (by petition)
Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12) or
Math 31, 32	Honors Calculus I and II (8) or
Math 41, 42, 43, 44	BMSS Calculus I, Probability, Linear Algebra and Calculus II (12)
EES 31, 32	Env. & Org. Biology and Laboratory (4)
MBio 33, 34	Cell & Molecular Biology and Laboratory (4)
Chm 21, 22	Introductory Chemical Principles and Laboratory (5)
CSc 11	Introduction to Structured Programming (3)
CSc 17	Structured Programming and Data Structures (4)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phil 128	Philosophy of Science (3)

plus additional electives in mathematics, probability, statistics, computing and information science, biology, chemistry, and physics.

Students planning to pursue graduate study in psychology should consider taking:

Psyc 395, 396	Thesis (6)
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Of particular interest to those students interested in a career in business administration is the five-year Arts B.A.-M.B.A. degree. In this option, a student majors in psychology, takes requisite courses in the College of Business and Economics, and then takes an additional year of study in business administration beyond the bachelor's degree. The Arts B.A.-M.B.A. program is described in Section III. There are, of course, many other possibilities. Students interested in formulating a particular career-based program of study should consult the department chairperson.

Honors Program in Psychology

The honors program permits majors of unusual academic ability and interest to explore topics in greater depth than the curricula normally allow. Under faculty supervision, a student normally spends the first semester of the senior year doing library research, learning the appropriate

methodology, and preparing a written proposal and oral presentation. In the second semester the proposal is implemented, culminating in a written honors thesis and oral presentation. Successful completion of this program results in "Departmental Honors" being affixed to the student's transcript.

Eligibility requirements. Eligible students must be psychology majors; have completed the first semester of the junior year with an over-all GPA of 3.0; and have completed a minimum of four psychology courses with a GPA of 3.3.

Interested students should contact the chairperson.

The Psychology Minor

The psychology minor consists of fifteen credit hours in psychology beyond the introductory course (Psych 1, 21). At least one of these courses must be above the 300 level. The student should consult the department chairperson no later than the fifth semester regarding course selection.

Undergraduate Courses

1. Introduction to Psychology (4)

Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human development, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems. Three hour lecture and one hour recitation per week.

21. (SSP 21) Social Psychology (3)

Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior, and social interaction. Not offered to students who have had Soc Psych 7.

31. Normal and Altered States of Consciousness (3)

Normal and altered states of consciousness are defined. These include waking, sleep, meditation, madness, and drug states. Newman

65. (Art 65) Perception and the Visual Arts (3)

Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess

77. Drugs and Behavior (3)

Basic principles of drug action in the central nervous system. Effects of stimulants, depressants, intoxicants and drug abuse on behavioral function. Clinical use of drugs in the treatment of various psychological and psychiatric disorders. Simon, Newman

81. Psychology and Law (3) fall

Contributions of psychological research to understanding the legal system. Eyewitness testimony; jury selection and decision making, sentencing; the rights of mental patients; psychologists as expert witnesses. Barrett

107. Child Development (3)

Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Psyc 1. Barrett, Phillips

108. Adolescent development (3)

Descriptions and explanations of cognitive, personality, and physical development during the adolescent and early adult years. The stresses of adolescence and the difficulties that individuals encounter in their initial attempts to function as adults. Prerequisite: Psyc 1. Phillips

109. (SSP 109) Adulthood and Aging (3)

Social science approaches to the latter two thirds of life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Hyland

110. Experimental Design and Statistical Analysis (3)

Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive

statistics; hypothesis testing theory and practice; correlation, chi-square, t-test, analysis of variance. Richter

117. Cognitive Psychology (3)

Information processing by human beings: attention, memory, language, and thought processes. Prerequisite: Psyc 1 or CogS 7. Malt, O'Seaghdha

121. Encountering Self and Others (3)

An experientially oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Pass-fail grading. Prerequisite: consent of the department chairperson. Newman

125. (SSP 125) Psychology of Small Groups (3)

Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein

131. (WS 131) Psychology of Women (3)

Biological, cross-cultural, sociological and psychological perspectives on women, with reference to personal experience where appropriate. Prerequisite: Psyc 1 or an introductory social relations course. Hyland

135. (SSP 135, Jour 135) Human Communications (3)

Processes and functions of human communication in relationships and groups. Rosenwein

140. (CogS 140, MFL 140) Introduction to Descriptive Linguistics (3)

Relationship between language and mind; formal properties of language; language and society; how languages change over time.

153. (SSP 153) Personality (3)

Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1, Psyc 21 or SSP 21. Williams, Wurf

154. Introduction to Clinical Psychology (3)

Survey of clinical psychology as a science and profession. Current psychological treatment approaches, assessment techniques, research strategies, and their empirical and theoretical foundations. Also discusses the training of clinical psychologists and ethical issues in clinical also discusses the research and practice. Prerequisite Psych 1. Williams

160. Independent Study (1-3)

Readings on topics selected in consultation with a staff member. Prerequisite: Psyc 1 and consent of the department chairperson. May be repeated for credit. Fulfills natural science or social science distribution requirements for students in the College of Arts and Science by petition only.

161. Supervised Research (1-3)

Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated once for credit. Prerequisite: Psyc 1 and consent of sponsor.

162. Psychological Field Work (1-3)

Work-Study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisite: Psyc 1 plus two additional psychology courses and consent of instructor.

165. (Art 165) Perception and the Visual Arts Studio (3)

Projects exploring the relationships between human visual perception and the visual arts. Visual thinking and creative problem solving. Prerequisite: Psyc 65 or Art 65 or consent of instructor. Shortess

171. Learning Processes and Applications (3)

Experimental data on animal and human conditioning and

learning. Applications to mental health, mental retardation, education. Prerequisite: Psyc 1.

176. Introduction to Cognitive Neuroscience (3)

Neurophysiological correlates of human cognitive and emotional processes such as imaging, dreams, hallucinations, attention, memory and language. Emphasis on cerebral lateralization, sleep and effects of brain damage on mental processes. Prerequisite: Psyc 1. Shortess

177. (BEB 177) Introduction to Behavioral Neuroscience (3)

Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: Psyc 1 or Introductory Biology. Shortess, Nyby, Simon

201. Industrial Psychology (3)

Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, job satisfaction and consumer behavior. Prerequisite: Psyc 1.

210. Experimental Psychology (4)

Data collection and research methods in various areas of psychology. Laboratory exercises, report writing and an independent research project. Prerequisites: Psyc 1 and 110 and consent of department chairperson.

277. (BEB 277) Behavioral Neuroscience Laboratory (2)

Nervous system structure; preparation of nervous tissues for microscopic examination; experiments on behavioral assays of nervous system function. Prerequisite: Psyc 177. Cundall, Schneider

305. Abnormal Psychology (3)

Examines research and theory on the patterns, causes, and treatment of various forms of abnormal behavior. Prerequisite: Psyc 1 or consent of the department chairperson. Williams

307. Seminar in Cognition (3)

Selected research and theory in cognitive psychology and cognitive science. Attention; knowledge; representation; memory; mental imagery; decision making; reasoning; nature of expertise; language processes; reading; effects of brain damage. Prerequisite: Psyc 117 or CogS 101 or consent of instructor. O'Seaghdha, Malt

308. (SSP 308) Seminar in Social Psychology (3)

Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit.

312. (SSP 312) Interpersonal Behavior in Small Groups (3)

Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Rosenwein

314. (SSP 314) Attitudes, Attributions, and Actions (3)

Social perception and cognition as studies in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change.

315. History of Modern Psychology (3)

Origin and development of major theories within perception, cognition, biological, clinical, personality, developmental, learning. Nineteenth and twentieth century thought to provide an overview of psychology as a discipline. Prerequisite: Psyc 1.

320. (Educ 320) Psychology of Language (3)

Study of the experimental and observational literature on

psychological processes involved in the production, comprehension, and use of language by adults. Malt

323. (SSP 323) The Child in Family and Society (3)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence.

331. Humanistic Psychology (3)
The literature of and metaphors underlying the humanistic point of view in psychology. These "models of man" are contrasted with models underlying other modes of psychological inquiry. Prerequisite: Psyc 1. Newman

333. (SSP 333, Govt 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Rosenwein

335. (BEB 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of special behavior patterns. Prerequisite: Consent of the department chairperson. Itzkowitz

337. (BEB 337) Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisite: Consent of department chairperson. Not open to students who have taken Biol 498. Itzkowitz

351. Cognitive Development in Childhood (3)
Piaget and alternative theoretical approaches. Research on development of memory, comprehension, communication, classification, and social cognition. Prerequisite: Psyc 107, 117, or CogS 101. Barrett

352. (SpEd 331) Emotional and Behavioral Disorders (3)
Definition, classification, etiology, treatment, and historical perspective of individuals with emotional and behavioral disorders.

354. Personality Assessment (3)
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisite: Psyc 1. Williams, Wurf

356. (SSP 356) Seminar in Personality Psychology (3)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: Psyc 153 or consent of instructor. Williams, Wurf

361. (SSP 361) Personality and Social Development in Adulthood (3)
Theories and current research. Prerequisite: Psyc 109 or consent of department chair. Hyland

363. Personality and Social Development in Childhood (3)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: Psyc 107 or 108 or 109 or consent of instructor. Phillips

371. Theories of Learning (3)
Critical evaluation of classical and contemporary theories of learning including review of relevant experimental research. Prerequisite: Psyc 171.

373. (BEB 373) Sensation and Perception (3)
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psyc 65 or 176 or 177. Shortess

374. Sensation and Perception Laboratory (1)
Laboratory exercise applying quantitative methods to the study of sensory processes. Prerequisites: Psyc 210; Psyc 373, previously or concurrently. Shortess

375. (Biol 375) Neuroanatomy of Behavior (3)
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Simon, Nyby

377. Seminar in Physiological Psychology (3)
Selected topics examining the physiological and/or genetic determinants of human and animal behavior. Prerequisite: Psyc 177 and consent of instructor. Shortess, Nyby, Simon

382. (BEB 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Nyby, Schneider, Simon

391. (SSP 391) Evaluation Research (3)
Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or 112 or consent of department chairperson. Herrenkohl

393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with faculty sponsor. Regular meetings with sponsor to give progress reports and receive feedback. Student reads relevant literature and writes report in APA format. May be repeated once for credit. Prerequisite: Psyc 210 or 161 and consent of sponsor.

395. Thesis (3)
Written report: Literature review and design of project in selected area of psychology. Intended for senior majors in psychology only. Prerequisite: consent of the chairperson.

396. Thesis (3)
Execution of project designed in Psych 395. Final report and oral presentation. Prerequisite: Psyc 395 and consent of the department chairperson.

For Graduate Students

The department of psychology offers the doctor of philosophy degree with specializations in biopsychology, cognition, development, and personality. The program emphasizes a commitment to research and the fostering of teaching skills. Students are trained primarily for positions at universities and those involving basic or applied research.

Requirements for a doctoral degree at Lehigh. The Graduate School requires 72 credit hours for a doctoral degree for those entering with a bachelor of arts or bachelor of science degree; 42 credit hours are required for those entering with the master of arts or master of science. All doctoral candidates are required to spend at least one year in residence, i.e., in full-time work toward the degree.

Requirements for a Ph.D. in the Department of Psychology:

Research

All graduate students are expected to be involved in research throughout their graduate careers. There are also several formal research requirements of the program.

First Year Project. First year students are expected to choose an adviser and begin to work on a research project as early as possible. A written and oral report of the student's research activities is made to the department.

Master's thesis. A master's thesis (usually empirical or data-based) is required. An oral presentation of the thesis is made to the department. Students entering with a master's degree may submit their thesis in fulfillment of the departmental thesis requirement with faculty approval.

Doctoral dissertation. This is an original piece of scholarly work usually empirical research, although original theoretical or historical research is possible with faculty approval.

Coursework

Core courses. All students must complete an approved course in at least 3 of the 4 specialization areas in the department

Psyc 421 and 422, Analysis and Design of Experiments. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

Psyc 400+, Graduate Seminars. Students must take at least four graduate seminars approved by the faculty.

Psyc 409, Professional Seminar. A one-credit, one semester course taken in the first semester of graduate study that covers research ethics, proposal writing, and instructional issues.

Teaching

Students are encouraged to participate in teaching as appropriate for their training throughout their graduate years. Normally, students begin as teaching assistants and progress to teaching independently.

General Examination

This is required for all doctoral candidates and must be passed at least seven months prior to the awarding of the degree. The student may opt for a major/minor or a major only exam; subareas to be covered on the exam are selected by the student in consultation with the student's general exam committee.

Evaluation

Graduate students are evaluated on their performance in course work, research, teaching, assistantship assignments, and the general examination. The faculty provides each student with a written evaluation of progress in the graduate program annually.

Financial Support

Support is available in the form of teaching and research assistantships, fellowships, and scholarships. There are special fellowships for minority students. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology are encouraged to apply.

How to apply

Applications for admission and financial aid may be obtained from the Department of Psychology. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination and advanced tests in psychology should be returned to the office of admission not later than February 1 of the year of admission. New students are normally accepted for entrance into the program only for the fall semester.

Graduate-Level Courses

402. (SchP 402, SpEd 402) Behavior Modification (3)

Theory and applications of behavior modification methods in classroom and clinical settings. Methods derived from operant, classical, and cognitive models. Topics include behavior analysis, charting behaviors, outcome research, and ethical and philosophical issues. Prerequisite: HD 400 or its equivalent.

403. Cognitive Psychology (3)

Theoretical and empirical issues in cognitive psychology. Prerequisite: Graduate standing or consent of instructor.

404. Biopsychology (3)

Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

405. Developmental Psychology (3)

Theoretical and empirical issues in developmental

psychology. Prerequisite: Graduate standing or consent of instructor.

406. Personality Psychology (3)

Theoretical and empirical issues in personality psychology. Prerequisite: Graduate standing or consent of instructor.

409. Professional Seminar (1)

Two hours of class meetings per week of first-and second-year graduate students to discuss teaching psychology and preparing for the profession. Shortess

412. (BEB 412) Metabolic Influences on Behavior (3)

Sensory systems that detect metabolic energy availability and affect the behavior of humans and other animals. Food intake and body weight regulation; sexual and parental behavior; aggression, learning; body temperature regulation. Prerequisite: BEB 404 and consent of instructor. Schneider

414. (BEB 414) Sexual Differentiation (3)

Genetic and hormonal events mediating the development and expression of sexual dimorphisms in physiology and behavior. Current theoretical models; emphasis on biochemical, neuroanatomical and molecular biological considerations. Prerequisite: BEB 404 and consent of instructor. Simon

415. (BEB 415) Psychopharmacology (3)

Mechanism of drug action in the central nervous system. Cell surface receptors and second messenger systems. Drug use/abuse and cellular changes mediating behavioral effects. Drug use in clinical therapy. Prerequisite: BEB 404 and consent of instructor. Simon

420. (BEB 420) Pheromonal Communication (3)

Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy/neuroendocrinology, and adaptive significance. Prerequisite: BEB 404 and consent of instructor. Nyby

421. Analysis and Design of Experiments (3)

First of a two-semester sequence covering a variety of issues in theoretical and applied statistics with emphasis on inferential statistics and analysis of variance. Richter

422. Analysis and Design of Experiments (3)

Continuation of Psyc 421. Prerequisite: Psyc 421. Richter

434. Seminar in Personality (3)

Selected topics in personality theory and research, including personality change, the self, personality consistency, and the relationships among thought, emotion, and behavior. Prerequisite: Psyc 406. Williams, Wurf

435. Abnormal Psychology (3)

Theoretical and empirical analysis of issues regarding the nature, measurement, causes, and treatment of various forms of abnormal behavior. Williams

441. Communicating Psychological Concepts (3)

How to organize facts and ideas into broader meaningful units that are readily communicable. Includes media aids. Prerequisite: consent of the department chairperson. Newman

448. Seminar in Psychology of Language (3)

Topics in language comprehension and production. Content will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O'Seaghdha

450. Special Topics in Mathematical Models and Statistics (3)

Selected topics in the application of mathematics to psychological research. May be repeated for credit. Richter

451. (Educ 451) Theories of Learning (3)

In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to

theories. (Intended for graduate students in the College of Education.)

453. Advanced Topics in Learning (3)

An intensive study with emphasis on current research of discrimination learning, avoidance learning, concept learning, problem solving, or verbal learning. May be repeated for credit. Prerequisite: Psyc 403 or consent of instructor. Richter

460. Special Study (1-3)

Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research Seminar (1-3)

Original research projects not connected with master's or doctoral theses are designed and executed in collaboration with the faculty. Students meet with the seminar director to critique each other's projects.

465. Teaching Internship (3-6)

The preparation and teaching of an undergraduate course with appropriate supervision by members of the faculty. Observation and evaluation of the intern via classroom visits and videotapes. May be repeated for credit.

471. Applied Psychology Internship (1-6)

Supervised, independent field work experience in e.g., industry, a medical setting, or a mental health setting. May be repeated for up to six hours credit.

472. (BEB) Special Topics in Physiological Psychology (3)

Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: Psyc 404 or consent of instructor. Nyhy, Schneider, Simon

473. (Coun 457) Personality and Adjustment (3)

Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director. Hyland, Williams

474. (Educ 474) Psychological Development in Childhood (3)

Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. (Intended for graduate students in the College of Education.) Phillips

475. (Coun 460) Theories of Psychological Counseling (3)

Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisite: admission to program in counseling.

476. Seminar in Cognition (3)

Selected topics in human information processing, including such areas as attention, memory, language and comprehension, and decision-making. Area of emphasis will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O'Seaghdha

478. (CogS 478) Ontological Psychology (3)

Principles and constraints for the modeling of psychological phenomena: perception, memory, knowing, emotions, consciousness, language, and rationality. Bickhard

480. Seminar in Cognitive Development (3)

Selected topics in cognitive development in infancy and childhood, including such areas as conceptual development, memory development, the development of reasoning abilities, and language acquisition. Emphasis will vary from year to year. Prerequisite: Psyc 405 or consent of instructor. Barrett

481. Selected Topics in Social and Personality Development (3)

Topics include emotional and sex-role development, peer relations, and social competence. Emphasis will vary from year to year. Prerequisite: Psyc 405 or 474 or consent of instructor. Phillips

482. Seminar in Adult Development (3)

Application of lifespan developmental theory and methodology to personality, social, and cognitive development in adulthood. Prerequisite: Psyc 405 or consent of instructor. Hyland

486. Seminar in Clinical Psychopharmacology (3)

Examination of diagnostic issues and pharmacological intervention strategies in the treatment of neuroses, psychoses, and other psychological/psychiatric problems. Emphasis on consideration of current primary references with evaluation through student presentations. Prerequisite: Psyc 404 or consent of instructor. Simon

487. Seminar in Visual Perception (3)

Examination of selected topics of current interest in visual perception from behavioral, cognitive, and neurophysiological approaches. Prerequisite: Psyc 404 or consent of instructor. Shortess

Major Programs in Behavioral and Evolutionary Biosciences (BEB) and Behavioral Neuroscience (BNS)

Please see course listings for Behavioral and Evolutionary Biosciences (BEB), and the program description for Behavioral Neuroscience (BNS) under those headings in the catalog.

Public Relations

See listings under Journalism and Communication.

Religion Studies

Professors. Norman J. Girardot, Ph.D. (Chicago), Laurence J. Silberstein, Ph.D. (Brandeis), *Philip and Muriel Berman Professor of Jewish Studies, and Director of the Philip and Muriel Berman Center for Jewish Studies.*

Associate professors. Kenneth L. Kraft, Ph.D. (Princeton); Michael L. Raposa, Ph.D. (Pennsylvania); Lloyd H. Steffen, Ph.D. (Brown); Lenore E. Chava Weissler, Ph.D. (Pennsylvania), *Philip and Muriel Berman Chair of Jewish Civilization, Chairperson.*

Assistant professor. Benjamin G. Wright, III, Ph.D. (Pennsylvania).

Religion studies is committed to the academic investigation of religion as an intrinsic and vital dimension of human culture. The scholarly study of religion is an integral facet of liberal education. The student of religion is engaged in the critical and interpretive task of understanding patterns of religious thought and behavior as aspects of the human cultural experience.

Religion studies is interdisciplinary in that it draws upon humanistic (involving historical and philosophical perspectives), social scientific (involving sociological, anthropological, and psychological perspectives) modes of inquiry. Religion studies is a cross-cultural, comparative discipline concerned with the character and significance of the major religious traditions of the world. The student of religion confronts ethical problems and basic issues of value and meaning raised by modern multicultural and technological society.

Major in Religion Studies

The major in Religious Studies consists of 30 credit hours of coursework (10 courses). Requirements include:

1. Rel 10 and 11 (exempted only with the permission of the major advisor and chairperson).

2. At least one course on a Western religious tradition (Rel 73, 75, 77, 111, 112, 114, 121, 125, 130, 132, 138, 139, 150, 152, 154, 155, 156, 158, 159), and at least one course on an Eastern religious tradition (Rel 62, 64, 65, 67, 160, 162, 164, 168, 169).

3. At least five courses at the 100 level or above.

In addition to this minimum distribution, we recommend a concentration in one of the major religious traditions, or in a comparative or thematic approach to the study of religion. The concentration should include at least four courses, where that is possible. Language study appropriate to the concentration is also desirable.

Students are particularly encouraged to consider a joint or double major with another major field from any of the three colleges at the university.

Departmental Honors

Religion Studies majors are admitted to honors by invitation of the departmental faculty toward the end of the student's junior year. To be eligible, a student must have attained at least a 3.25 average in his or her major program by the end of the junior year. Upon admittance to honors, the student will work out a special program of studies for the senior year with the major advisor (typically involving special directed reading courses, a senior essay, etc.).

Minor in religion studies. The minor in religion studies consists of a total of fifteen credits. The specific courses to be taken by each student are to be decided upon jointly by the student and the departmental advisor. Ordinarily, the student will be expected to take Rel 10 or 11 unless specifically exempted by the departmental chairperson.

Undergraduate Courses

10. Introduction to the Study of Religion (3)

Basic issues and methods in religious studies. "What is religion?": the problem of definition. Role of religion in individual and group life. Staff

11. Introduction to the Religions of the World (3)

At least one major religious tradition of the West (Judaism, Christianity, Islam) and of the East (Hinduism, Buddhism, Chinese and Japanese religion); compares Western and Eastern religions with reference to such topics as the self, salvation, the sacred. Staff

13. Greek New Testament

Readings in the Greek New Testament. Grammar review. Prerequisite: Greek 1 & 2. Wright

62. Religions of India (3)

Origin, development and meaning of the major forms of Indian religious traditions. Attention to elite and popular forms of Hinduism, Yoga, early Buddhism.

64. Religions of China (3)

History and meaning of the major forms of Chinese religion—especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an/Zen), and popular religion. Girardot

65. Religions of Japan (3)

A survey of Japan's diverse religion heritage and its impact on contemporary culture. Japanese approaches to the self, the world, and the sacred are considered in comparative perspective. Topics covered include: Shinto, Buddhism, Zen, Confucianism, the Way of the warrior, folklore, and postwar movements. Kraft

67. (Hist 67) Introduction to Japanese Civilization (3)

The history and culture of Japan from its origins to the present. Special consideration will be given to the rise and fall of the warrior class, developments in art and religion, the

dynamics of family life, and Japan's "economic miracle." Kraft

73. Introduction to Judaism (3)

Development of traditional Judaism; readings in the Bible, the Talmud, and selected mystical texts. Discussions will focus on the diverse ways in which Judaism has been understood and interpreted up until the end of the 18th century. Silherstein, Weissler

75. Introduction to Christianity

Introduction to the Christian tradition from its early variety and subsequent classical definition in the church councils up to the enlightenment. Special emphasis will be placed on the multiform interpretations of the Christian message.

77. The Islamic Tradition (3)

Origin and development of classical Islam. Topics include Muhammad and the Koran; legal, theological, and ritual institutions; the Caliphate; Islamic mysticism; Islamic cosmology and Islamic science.

111. The Hebrew Bible/Old Testament (3)

Religious expression of the Hebrews, Israelites, and Jews as found in the Hebrew Bible (Christian Old Testament). Historical, literary, and newer socio-historical approaches. Near Eastern context of Hebrew religion; the Patriarchs; the Exodus; the monarchy, prophecy, Exile and Return. Wright

112. Varieties of Judaism in the Greco-Roman World (3)

The variety of approaches to Judaism in the period following the Babylonian exile through the second century C.E. The literature studied will include Apocrypha, Pseudepigrapha, and the Dead Sea Scrolls. Wright

114. Christian Origins: New Testament and the Beginnings of Christianity (3)

Early Christianity from its beginnings until the end of the second century. The New Testament; Jewish matrix of Christianity; Hellenistic context; Apostolic Fathers; non-biblical Jesus traditions; diversity in early Christianity. Attention to primary texts. Wright

121. Sources for the Life of Jesus (3)

Ancient sources that claim to provide information about Jesus of Nazareth. Approaches taken to Jesus' life and career; early Christian interpretations of the significance of Jesus; methodology in assessing evidence for the historical Jesus and his message. Wright

125. Heresy and Orthodoxy: Varieties of Christianity in the First Three Centuries (3)

Examines the development of Christianity until the end of the third century. Compares the views of different groups about the significance of Jesus. Who were the proto-orthodox? Jewish Christians? Gnostics? What did they think? Why were some branded heretics by others? Wright

130. The Mystical Tradition: Judaism

Explores the history of the quest to know God, through mystical experience or theosophical speculation, as found in Jewish tradition. Examines such issues as the tensions between institutional religion and personal religious experience, between views of God as immanent in the world of transcendent of it, and between imagery for God and religious experience of God. Weissler

132. Hasidic Tales (3)

Examines the mysterious and beautiful tales told by Hasidim, participants in the movement of spiritual revival which arose within 18th century Judaism. Compares hasidic tales to European fairy tales, and shows how later writers transformed hasidic narratives to express their own religious or literary meanings. Weissler

138. Women in Jewish History (3)

Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women,

and the contemporary feminist critique of traditional gender roles. Weissler

139. (Anth 139) Jewish Folklore

Traditional culture and lore of European Jews from 18th century Central Europe to 19th century Eastern Europe. Shift from folk to ethnic culture as Eastern European Jews emigrated to North America in the 20th century. Nature of tradition and ethnicity; difference made by gender in experiencing traditional culture; relationship between "official" religion and popular traditions. Readings supplemented by films, field trips, and student field work. Weissler

142. (Anth, STS, 142) Prehistoric Religion and Technology (3)

Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot

150. Judaism in the Modern World

Fundamental themes in the experience of modern Jewry; confrontation with secular culture; crisis of religious faith; Zionism and the renewal of Jewish nationalism; the problem of Jewish identity in America; and the impact of the Holocaust. Silberstein, Weissler

152. American Judaism (3)

Diverse cultural and social forms through which American Jews express their distinct identity. Is American Jewry an example of assimilation and decline or creative transformation? What, if anything, do American Jews share in common? Compatibility of Judaism with individualism, pluralism, and voluntarism. How have the Holocaust and the State of Israel shaped the self-understanding of American Jewry? Silberstein

154. (Hist 154) The Holocaust: History and Meaning (3)

The Nazi holocaust in its historical, political and religious setting. Emphasis upon moral, cultural and theological issues raised by the Holocaust.

155. Jewish Thought since the Holocaust

Reactions to the Holocaust by major Jewish thinkers such as Wiesel, Rubenstein, Fackenheim, Buber, Herschel, Schulweis, and Berkovitz. Focus on the problem of evil and its relationship to religious faith. Silberstein

156. Israel, Zionism, and the Renewal of Judaism (3)

New interpretations of Judaism, the Jewish community and Jewish history developed by Zionist thinkers. Diverse currents within Jewish nationalist thought and critical responses to Zionist ideology. Silberstein

157. (Hist 157) The Renaissance and Reformation (3)

The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor

158. (WS 185) Sex and Gender in Judaism: The Feminist Critique (3)

Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God, and God language, communal power, the marriage and divorce. Silberstein

159. Roman Catholicism in the Modern World (3)

A survey of the various intellectual, cultural, political and ecclesiastical developments that have shaped contemporary Roman Catholic life and thought. Raposa

160. The Taoist Tradition (3)

Consideration of the religious and cultural significance of Taoism in its various historical forms. Primary attention will be given to a close reading of some of the most important texts of the early philosophical tradition (e.g. *Tao Te Ching*, *Chuang Tzu*) and of the later religious tradition (e.g. *Pao P'u*

Tzu and other selections from the *Tao Tsang*).

Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics", "a Taoist on Wall Street", and "the Tao of Japanese Management"). Girardot

162. Zen Buddhism (3)

History, doctrines, and practices of Zen Buddhism in China, Japan, and the West. Monastic life, notable Zen masters; Zen's cultural impact; enlightenment. What aspects of the Zen tradition remain relevant today? (Optional meditation workshop.) Kraft

164. (IR 164) Japan's Response to the West (3)

A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the US, the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft

168. Buddhism in the Modern World (3)

Contemporary Buddhism in Asia and the West; emphasis on Buddhist responses to political and social issues. Kraft

169. Classics of Asian Religion (3)

Sacred scriptures of Asia and an introduction to the religions they represent. What do these texts teach about reality, humanity, divinity, and society? How is the path of spiritual practice presented in the different traditions? Kraft, Girardot

170. Comparative Christianities (3)

Christianity as a religious system; African-American Church; Christianity in Asia and Japan; liberation interpretations of Scripture (Central and South America); Christian dialogue with Hinduism. Steffen

172. The Jewish-Christian Encounter (3)

Historical analysis of relations between Jewish and Christian communities. Attention to doctrinal and liturgical similarities and differences. Special emphasis on the twentieth century.

174. Contemporary Theology (3)

Major twentieth century movements within Christian and Jewish theology understood as responses to the problems of modern times. May be repeated for credit as the subject matter varies. Raposa

180. (Hist 180) Religion and the American Experience (3)

The historic development of major American religious groups from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. Raposa

181. (Phil, Hist, 181) Reason and Religious Experience (3)

A critical look, from a philosophical perspective, at some fundamental problems of religion: The nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Raposa

183. Religion, Ethics, and Society (3)

Religious and secular modes of ethical analysis. Application of analytical methods to controversial moral issues, both in the social realm (capital punishment, abortion, defective newborns) and problems of personal disorder (heavy drinking and drug abuse). Steffen

184. (WS 184) Religion, Gender, and Power (3)

Gender differences as one of the basic legitimations for the unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberstein

185. Myth and Meaning in Religion (3)

Inquiry into the meaning of religious symbols, myths and rituals. Historical perspectives; philosophical and methodological problems. Readings in the works of Otto, Cassirer, Eliade, and Levi-Strauss. Girardot, Raposa

187. Science, Technology, and the Religious Imagination (3)

Impact of the scientific and technological culture on the Western religious imagination. Roots of science and technology in religious ideas and images. Ways of knowing and concepts of experience in religion and science. Raposa

188. Religion and Literature (3)

Religious themes in the modern novel or the spiritual autobiography. Melville, Tolstoy, Camus, Updike, Walker, and Morrison; or Woolman, Tolstoy, Malcolm X, Wiesel, Frederick Douglass, Sojourner Truth, Kukai. Steffen

189. Religion and the Visual Arts (3)

To what extent does the process and production of artistic images relate to visionary experience in the history of world religions, and expose a religious dimension in life? In what sense is an artistic vocation similar to the religious vocation of a shaman, prophet, or saint? In what way do artists and religious figures respond to, change, and create the "real" world? Girardot

213. (Clss 213) Ancient Roman Religion (3)

Religious experience of the Roman people from prehistory to end of the Empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials.

221. Topics in Asian Religions (3)

Selected thematic and comparative issues in different Asian religious traditions. Topics may include Buddhism and Christianity, Religion and martial arts, Asian religions in America, Taoist meditation, Zen and Japanese business, Buddhist ethics. May be repeated for credit as the subject matter varies. Girardot, Kraft

222. Topics in Western Religions (3)

Selected historical, thematic, and comparative issues in Judaism, Christianity, and Islam. May be repeated for credit as the subject matter varies.

224. (Phil 224) Topics in the Philosophy of Religion (3)

Selected problems and issues in the philosophy of religion. May be repeated for credit as the subject matter varies. Prerequisite: Rel 181 or consent of the department instructor. Raposa

225. Topics in Religion and Ethics (3)

Analysis of various moral problems and social value questions. Possible topics include: environmental and non-human animal ethics; medical ethics; drug and alcohol abuse; spiritual meaning of anorexia.

237. (Phil 237) Kierkegaard and Nietzsche (3)

Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence.

251. (Clss 251) Classical Mythology (3)

Myth, religion and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of myth. Cross-cultural material.

335. (Anth 335) Religion, Symbolism and Cosmology (3)

How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel

355. (Hist 355) European Intellectual History (3)

Political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Baylor

359. (SSP 359) Sociology of Religion (3)

Religion as a central institution in society. Social functions

provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Thomas

361. Fieldwork (3)

Opportunity for students to work, or observe under supervision, religious organizations or institutions. Consent of chair required.

371. Directed Readings (1-3)

Intensive study in areas appropriate to the interests and needs of students and staff.

Russian Studies

Oles M. Smolansky, Ph.D. (Columbia), University Professor of International Relations, *program director*.

Professors. Nicholas W. Balabkins, Ph.D. (Rutgers); Donald D. Barry, Ph.D. (Syracuse); M. Rajan Menon, Ph.D. (Illinois); Oles M. Smolansky, Ph.D. (Columbia).

Assistant professor. Mary A. Nicholas, Ph.D. (Pennsylvania).

Adjunct professor. Winfred Kohls, Ph.D. (Berkeley).

Lecturer. Edward Manouelian, ABD (Harvard).

Russian Studies Major

The major in Russian Studies is an interdisciplinary program designed to provide students with a broad exposure to the Russian language and to Russian and Soviet culture. Courses in language, literature, history, politics, foreign policy, and economics, as well as the possibility of study in the USSR, are part of the curriculum for this major. The required and elective courses fit in well with a traditional liberal arts education. At the same time, the emphasis on area studies provides students with a focus for their intellectual efforts and a specialization that can be pursued, in graduate school or in a variety of public and private sector careers, after graduation.

The major in Russian studies require 36-40 credit hours, distributed as follows:

A. Required Courses

I. Language and Literature: two years of college Russian, course selection based on placement: 12-16 credit hours.

II. Russian History

Hist 261	A History of Russia to 1855 (3)
Hist 262	A History of Russia, 1855 to Present (3)

III. Russian Politics and Foreign Policy

Govt 361	Soviet and Post-Soviet Politics (3)
IR 168	Diplomacy of Russia Since 1945 (3)
IR 169	The Soviet Collapse and World Politics (3)

B. Elective Courses

The student will select at least three courses from the following list:

IR 167	Diplomacy of Russia to 1945 (3)
IR 367	Seminar in the International Relations of Russia and Eastern Europe (3)
Govt 318	Communist Political Systems (3)
Eco 309	Comparative Economic Systems (3)

Other Russian language and literature courses.

Other courses approved by the Director of the Program (e.g., relevant courses offered through IVAIC or at other institutions).

Field Study in the Soviet Union (e.g., faculty-led study trips offered under special topics or approved study-abroad programs).

Any substitutes for required or elective courses must be

approved by the Director of the Russian Studies Program.

Russian Studies Minor

The minor in Russian Studies is an interdisciplinary program designed to provide a broad range of study of the former Soviet Union. It can be considered the beginning of a specialization in the area that can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.).

The program may also be of general interest to nonspecialist students who wish merely to do focused work on the culture and society of the former USSR.

The minor in Russian Studies requires eighteen to twenty-two credit hours of formal course work, chosen in consultation with the program director, Oles M. Smolansky, department of International Relations.

required courses (15-19 hours)

two semesters of college-level Russian (at least three credit hours each), based on the student's level of competence; or two semesters of Russian literature in translation (6-10)

Govt 361	Soviet and Post-Soviet Politics (3)
Hist 261	A History of Russia to 1855 (3) or
Hist 262	A History of Russia to Present (3)
IR 167	Diplomacy of Russia to 1945 (3) or
IR 168	Diplomacy of Russia Since 1945 (3)

elective course (3 credit hours); one course from the following: any other Russian-language course (3)

any other Russian literature course (3)

Govt 318	Communist Political Systems (3)
Eco 309	Comparative Economic Systems (3)
Hist 261 or 262	(whichever is not taken under Section 1) (3)
IR 167 or 168	(whichever is not taken under Section 1) (3)
IR 367	Seminar in the International Relations of Russia and Eastern Europe (3)

Special Topics courses in other areas such as psychology or social relations, with permission (3)

Field Study in the former Soviet Union for academic credit under Special Topics (3)

Other courses approved by the director of Russian Studies.

School Psychology

See listings under Education.

Science, Environmental and Technical Writing

See listings under Journalism and Communication.

Science, Technology and Society

Stephen H. Cutcliffe, Ph.D. (Lehigh), *program director*.
Steven Louis Goldman, Ph.D. (Boston), *Andrew W. Mellon Professor in the Humanities*.

The Science, Technology and Society (STS) Program is the product of a continuing intercollege effort to create a common ground from which to explore the relations between science, technology and society: between ideas, machines and values.

The STS Program serves as a focal point for a wide range of courses that study the natures of science and of technology, and analyze their social and personal implications. It lends coherence and visibility to offerings otherwise dispersed throughout the catalog.

STS Studies Major

The major in Science, Technology and Society Studies prepares students for graduate study or for a wide variety of career opportunities including policy analysis, planning, or community relations with public or private sector agencies concerned with the social relations of scientific research and technological innovation. The intrinsically cross-disciplinary character of science-technology-society interactions is reflected in the B.A. requirements. Majors must complete a minimum of 34 credit hours in STS courses, listed below, together with at least 18 credit hours in any traditional academic discipline: engineering, physical or life science, the humanities, or the social sciences. This collateral set of courses should be chosen in consultation with the Program Director to provide the foundation needed to engage STS Studies issues in which that discipline is implicated. The senior seminar and project provide an opportunity for students to integrate the knowledge they have gained and the skills they have acquired, in the course of guided research on a topic of special interest to them. Additional opportunities for student research are available, especially through STS 181: Independent Study.

STS Studies is a social science major in the College of Arts and Science, and majors must fulfill the College's B.A. distribution requirements. A detailed description of the STS Studies major requirements and a suggested roster follows.

Detailed Description of STS Major Requirements

A. Required STS Courses (34 hours)

STS 11: **Technology and Human Values**

STS 12: **Engineering and Society**

History 7: **The Machine in America**

STS/Journalism 124: **Politics of Science or**

Govt 115: **Technology as Politics**

Philosophy 128: **Philosophy of Science or**

Philosophy 228: **Topics in Philosophy or Science**

Economics 1: **Economics 1, 11, or 12**

Methods Course—choice from available courses:

Government 321; Economics 145;

Psychology 110; Social Relations 111.

STS 381: **Senior Seminar**

STS 382: **Senior Project**

Two additional advanced courses from the list of approved STS Studies courses.

B. Concentration in a complementary discipline (minimum of 18 hours to be chosen in conjunction with STS Studies advisor; *or* double major).

C. Science and Mathematics Requirement

Students must fulfill the College's regular B.A. distribution requirements of three courses in the Natural Sciences (9 hours); and one course in Mathematical Sciences (3 hours). At least one of the courses in the Natural Sciences must also include the associated laboratory course. These courses should be chosen in consultation with the advisor.

Suggested STS Major Roster

Year 1			
A&S 1	(1)	Fr. Sem./Elective	(3)
Fr. Sem./Elective	(3)	English 2	(3)
English 1	(3)	History 7	(3)
Science Elective	(3-4)	Math	(3)
Elective/Eco	(3 or 4)	Science Elective	(3-4)
Course			

Year 2			
STS 11	(3)	STS 12	(3)
Collateral STS - 1	(3)	STS 124/Jour 124 or Govt 115	(3)
Humanities	(3)	Collateral STS - 2	(3)
Elective			
Science Elective	(3-4)	Elective	(3)

Elective/Eco Course	(3 or 4)	Humanities Elective	(3)
Year 3			
Collateral STS - 3	(3)	Collateral STS - 4	(3)
Methods Course	(3)	STS Elective	(3)
Humanities Elective	(3)	Elective	(3)
Philosophy 128 or 228	(3)	Elective	(3)
Elective	(3)	Elective	(3)
Year 4			
Collateral STS - 5	(3)	Collateral STS - 6	(3)
STS 381 Senior Seminar	(3)	STS 382 Senior Project	(3)
Elective	(3)	STS Elective	(3)
Elective	(3)	Elective	(3)
Elective	(3)	Elective	(3)

STS Studies Minor

The Program also offers a minor in *Science, Technology & Society Studies* which is open to all undergraduates. Students electing the minor must take a set of five courses (fifteen hours) clustered about one of three areas of concentration:

- (1) science, technology and society;
- (2) science, technology and human values;
- (3) science, technology and culture.

Minors must take STS 11: *Technology and Human Values*. At least three of the five courses should be taken in one of the above areas, and at least one course in any other area.

A list of all courses eligible for STS Studies follows, divided according to concentration. Students should consult with the Program Director when selecting courses for either the major or the minor.

Science, Technology and Society Courses

11. Technology and Human Values (3)

Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from literature, art, philosophy, history, folklore, and film. Cutcliffe

12. Engineering and Society (3)

An examination, from the perspective of its social context, of engineering as a distinctive problem-solving discipline. The roles of design, modeling, testing, safety analysis, product and client in defining engineering problems and acceptable solutions to them. Goldman, Nagel

121. Technology, Engineering and Public Policy (3)

The commercial nuclear power industry, civilian space programs and genetic engineering serve as vehicles for examining the interaction of political, social and personal values with technical knowledge in establishing research and innovation policies. Goldman

124. (Jour 124) Politics of Science (3)

Organization of the U.S. scientific community and how it interacts with government, the mass media and the public. Friedman

141. Science and Technology Studies in East Asia (3)

The development of science and technology in East Asia with emphasis on Japan and China. Cultural and religious influences, both internal and external, and interactions with the West, as illustrated by the development of bronze technology, ceramics and architecture. Factors in Western and Japanese society that have contributed to the rapid growth of Japanese technology as well as limits to future growth of technology in East Asia. Notis

145. (Hist 145) Introduction to the History of Science (3)

The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century. Goldman

181. Independent Study fall-spring

Prerequisite: consent of the program director.

341. Issues in American Competitiveness (3)

Problems in U.S. industrial competitiveness; social, political, technological solutions. Goldman, Nagel

381. Senior Seminar (3)

In-depth study of selected topics in science, technology and society. Subject matter may vary from semester to semester. Prerequisite: STS 11 or consent of program director. Goldman, Cutcliffe

382. Senior Project (3)

Continuation of STS 381. Students conduct and present independent research projects on STS topics of special interest. Prerequisite: STS 381. Goldman, Cutcliffe

Other STS courses. The following courses, appropriate to STS Studies, are offered by various departments. Course descriptions may be found under the catalog entry for the individual department. New courses are frequently added to this list and announced in bulletins published by the STS Program. For further information, please contact the program director.

I. Science, Technology and Society

Anth 151	Utopias and Alternative Communities—Frankel
CSc 252	Computers and Society—Barnes
Eco 311	Environmental Economics—Munley
Eco 314	Energy Economics—McNamara
Geol 11	Environmental Geology—Evenson
Govt 111	The Politics of Environment and Natural Resources—Wurth
Govt 115	Technology as Politics—Wurth
SSP 135	Medicine and Society—Lasker
SSP 327/Jour 327	Mass Communication and Society—Rosenwein
Jour 125	Environment, Public, and Mass Media—Friedman
STS 12	Engineering and Society—Pense and Goldman
STS 121	Technology, Engineering and Public Policy—Goldman
STS/Jour 124	Politics of Science—Friedman
STS 341	Issues in American Competitiveness—Goldman, Nagel

II. Science, Technology and Human Values

Engl 89	Speculative Fiction—Arbur
Engl 187	Themes in Literature: Utopian Literature—Harson
Mus 253	Composition I: Electronic and Acoustic Techniques—Salerni
Mus 254	Composition II—(Cont. of Mus 253)—Salerni
Psyc 65	Perception and The Visual Arts—Shortess
Psyc 165/Art 165	Perception and the Visual Arts Studio—Shortess
Phil 115	Business Ethics—Staff
Phil 116	Medical Ethics—Staff
Phil 117	Engineering Ethics—Dillon
Phil 128	Philosophy of Science—Bearn
Phil 228	Topics in the Philosophy of Science—Goldman
Phil 250	Minds of Men and Robots—Melchert
RS 187	Science, Technology & The Religious Imagination—Raposa
RS 142/Anth 142	Prehistoric Religion and Technology—Girardot
STS 11	Technology and Human Values
Thtr 161	Theater Design and Engineering—Milet

III. Science, Technology and Culture

Arch 207	Renaissance Architecture—Staff
Arch 209	Architecture and Ideas since 1750—Thomas
Arch 210	20th-Century Architecture—Zaknic
Arch 361/ Hist 361	Evolution of Highrise Building Construction—Peters
Arch 363/ Hist 363	Evolution of Long-Span Bridge Building—Peters
Arch 365/ Hist 365	Evolution of the Modern Building Process—Peters
Clss 108	Ancient Technology—Small
Clss 204/ Arch 204	Ancient City and Society—Small
Hist 7	Machine in America—Smith
Hist 8	History of Medicine in America—Ellis
Hist 31	History of Japanese Industrialization Since 1800—Cooper
Hist 111	Engineering in the Modern World—Smith
Hist 301	Seminar in the History of Technology—Simon, Smith, Cooper
Hist 307	History of American Industrial Technology—Smith
Hist 315	American Environmental History—Cutcliffe
Hist 337	History of Medical Thought—Ellis
Hist 339	Topics in American Public Health—Ellis
Hist 340	Topics in American Medicine—Ellis
STS 141	Science and Technology Studies in East Asia—Notis
STS/Hist 145	Introduction to the History of Science—Goldman
STS/Mat 221	Materials in the Development of Man—Notis

Social Psychology

See listings under Sociology and Anthropology.

Sociology and Anthropology

Professors. Donald T. Campbell, Ph.D. (Berkeley), *University Professor of Social Relations and Psychology*; Barbara B. Frankel, Ph.D. (Princeton); John B. Gatewood, Ph.D. (Illinois); Roy C. Herrenkohl, Ph.D. (N.Y.U.); Judith N. Lasker, Ph.D. (Harvard), *chairperson*; James R. McIntosh, Ph.D. (Syracuse); Robert E. Rosenwein, Ph.D. (Michigan). **Associate professor.** David B. Small, Ph.D. (Cambridge). **Assistant professors.** Joan Z. Spade, Ph.D. (SUNY-Buffalo); Nicola Tannenbaum, Ph.D. (U. of Iowa); Melvin E. Thomas, Ph.D. (Virginia Polytechnic). **Adjunct professor.** Raymond Bell, Ed.D. (Lehigh).

The disciplines of sociology and anthropology are concerned with the study of human beings in relationships with others, i.e., with social relations. As such, they encompass the study of the broadest range of human social activities, from the comparative examination of widely divergent cultures and societies to the inner life of individuals as this influences social behavior.

The common goal of the department's diverse offerings is to foster both self- and societal-awareness. Departmental courses provide students with the analytic skills necessary to understand and conduct social research as well as a broad range of topical courses to choose among. To study social relations is to develop a sense of the influences that have shaped one's past and pattern one's future.

But self-awareness is only a beginning. Human behavior occurs within diverse settings, groups and other

collectivities. Coping with and resolving conflict, reducing strain and tension, and managing and building cooperation are central themes of study in departmental courses. Whether in the study of primitive kinship systems, the elements of wealth and power, or the messages of nonverbal behavior, one comes closer to an understanding of social life in organizations, organizational behavior, and the structure of groups and societies.

The department offers three Bachelor of Arts majors: Social Relations (the interdisciplinary major), Anthropology, and Sociology/Social Psychology. The three programs are parallel in structure and requirements. Each consists of 38 credit hours of course work: 17 credits of core courses (6 in introductory level courses and 11 in theory and methodology) and 21 credits of major electives. The Social Relations major is an interdisciplinary program for students desiring a wider familiarity with social science fields, whereas the Anthropology and Sociology/Social Psychology majors are for students desiring more traditional, disciplinary programs of study.

Research Opportunities. It is the explicit aim of the department to involve majors, minors and other interested students in the ongoing research activities of faculty members. Second-semester sophomore, junior and senior students interested in a supervised research experience are encouraged to consult with the department chair or talk with the appropriate faculty member. Course credit may be received for research experience.

Fieldwork Opportunities. The department maintains close, working relationships with a variety of social agencies and institutions in the area. Majors may earn course credit by carrying out supervised work in field settings, e.g., hospitals, private and public agencies devoted to social services, courtrooms, prisons, etc. This useful experience allows a student to apply the concepts learned in the classroom to a field setting and to evaluate vocational aspirations and interests.

Students interested in social work may take courses in the Social Work Education Program, an undertaking of the Lehigh Valley Association of Independent Colleges.

Senior Thesis. All majors are encouraged to do an independent research culminating in a Senior Thesis, and this is especially recommended for students intending to go on to graduate or professional school. The best time to begin discussing possible projects with faculty is during the second-semester of the junior year. The department chairperson should be consulted for further details.

Departmental Honors. To be eligible for departmental honors, students must have at least a 2.80 GPA overall and at least a 3.25 GPA in the major. In addition, students pursuing honors must take SR, Anth, or SSP 399 and write a thesis during their senior year. Awarding of departmental honors is contingent on both the quality of the thesis, as judged by three of the department's faculty, and the candidate's GPA at time of graduation.

B.A. Major Programs

Social Relations

Introductory (6 credits, from two of the disciplines)	
Anth 11	Sociocultural Anthropology (3) spring
Anth 12	Human Evolution and Prehistory (3) fall
SSP 5	Introductory Sociology (3) fall
SSP 21	Social Psychology (3) spring

Theory and Methodology (11 credits)

SR 111	Research Methods and Statistics (4) fall
SR 112	Computer Applications in Social Relations (4) spring
SR 381	Development of Social Theory (3) fall

Major Electives (21 credits)

Seven additional courses in social relations, with at least four

at the 300-level or above. These must be chosen in such a way that, in conjunction with the introductory courses, the student completes at least two courses in each of anthropology, sociology, and social psychology. No more than 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Anthropology

Introductory (6 credits)

- Anth 11 Sociocultural Anthropology (3) spring
 Anth 12 Human Evolution and Prehistory (3) fall

Theory and Methodology (11 credits)

- SR 111 Research Methods and Statistics (4) fall
 SR 112 Computer Applications in Social Relations (4) spring
 SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)

Seven additional courses in anthropology, with at least four at the 300-level or above. (One of these seven may be a SR, or SSP course.) No more than 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Sociology/Social Psychology

Introductory (6 credits)

- SSP 5 Introductory Sociology (3) fall
 SSP 21 Social Psychology (3) spring

Theory and Methodology (11 credits)

- SR 111 Research Methods and Statistics (4) fall
 SR 112 Computer Applications in Social Research (4) spring
 SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)

Seven additional courses in sociology and/or social psychology, with at least four at the 300-level or above. (One of these seven may be a SR or Anth course.) No more than 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Note: Students majoring in anthropology or in sociology/social psychology can use the following SR courses to fulfill the major electives requirement as if these were Anth or SSP courses, respectively:

- SR 365 Fieldwork in Social Relations (1-4)
 SR 395 Methods in Observation (3)
 SR 416 Quasi-Experimentation and Program Evaluation (3)
 SR 461 Seminar in Social Relations (1-4)

Minor Programs

Social Relations: One introductory course (Anth 11 or 12, SSP 5 or 21) and twelve additional credits at the 100-level or above, with at least three credits in each of anthropology, sociology, and social psychology.

Anthropology: Anth 11 or 12 and twelve additional credits at the 100-level or above in anthropology.

Sociology: SSP 5 and twelve additional credits at the 100-level or above in sociology.

Social Psychology: SSP 21 and twelve additional credits at the 100-level or above in social psychology.

Undergraduate Courses

SR 41. (WS 41) Human Sexuality (3)

Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior.

SR 100. Seminar in Social Relations (1-4)

Topics in social relations. May be repeated for credit.

SR 111. Research Methods and Statistics (4) fall

Research skills in anthropology, sociology and social psychology. Problem formulation; research design; methods and measures; analysis and interpretation of data. Emphasis on the use of statistics in the research process.

SR 112. Computer Applications in Social Relations (4) spring

Uses of micro- and mainframe computers in the social sciences. Data management; statistical analysis; simulations. Weekly laboratory sessions. Prerequisite: SR 111 or consent of department chair.

SR 118. Close Personal Relationships (3)

Dynamics of development, maintenance and dissolution of relationships with family, close friends, lovers and spouses. Life cycle of relationships, attraction, communication.

SR 331. Social Perspectives on Death and Dying (3)

The meaning of the end of life in various societies, especially the United States. Sociological, anthropological, and psychological perspectives on dying as a process, and on death as an event, combined with philosophical and ethical considerations. Topics to be considered include euthanasia and "extraordinary means" to maintain life from neonate to elderly, funeral practices, stages of dying, hospices, and the social milieu and family relationships of the dying person.

SR 363. Seminar in Social Relations (1-4)

Selected social science topics. May be repeated for credit.

SR 365. Fieldwork in Social Relations (1-3)

Supervised work experience and observation in a variety of field settings, e.g., hospitals, social services, public agencies, private organizations. May be repeated once for credit. Prerequisite: open only to the department's majors. McIntosh

SR 381. Development of Social Theory (3) fall

Comparative study of social theory.

SR 395. Methods in Observation (3) alternate years

Naturalistic and participant observation in uncontrolled field settings. Frankel or Rosenwein

SR 399. Senior Thesis (3)

Research during senior year culminating in senior thesis. Required for social relations majors seeking departmental honors. Prerequisites: consent of the department chairperson.

Anthropology

Anth 11. Sociocultural Anthropology (3) spring

Human behavior in cross-cultural perspective. Variations in kinship reckoning, political organization, economic and religious life in comparative perspective. Particular non-Western peoples: films and readings.

Anth 12. Human Evolution and Prehistory (3) NS fall

Introductory biological anthropology and prehistory. Adaptive function of human culture and its relation to biological evolution. Mechanisms of evolution, nonhuman primate morphology and behavior, hominid fossil record, cultural beginnings, and survey of world prehistory.

Anth 100. Seminar in Anthropology (1-4)

Topics in anthropology. May be repeated for credit.

Anth 112. (Clss 112) Doing Archaeology (3)

Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small

Anth 121. (Clss 121) Environment and Culture (3)

Impact of environment upon cultural variability and change.

Comparative study of modern and past cultures and their environments as well as current theories of human/environmental interaction. Small

Anth 123. (WS 123) The Cultural Construction of Gender (3)

Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum

Anth 125. Anthropology of Peasant Peoples (3)

Comparative study of peasants—peoples who depend on small-scale agriculture and comprise 80% of the world population. Cultural, political, and economic bases of peasant societies and their future prospects. Tannenbaum

Anth 127. (Clss 127) Early Civilization (3)

Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and New World. Similarities and differences in economics, politics, social organization, and religion. Small

Anth 128. Urban Ethnology (3)

Cross-cultural study of the city as a social milieu. Comparison of methods and strategies for research in urban settings, and the explicit and implicit theories of urban life associated with these. Field projects will use Bethlehem's South Side as an ethnographic laboratory. Frankel

Anth 139. (Rel 139) Jewish Folklore (3)

Traditional culture and lore of European Jews from 18th century Central Europe to 19th century Eastern Europe. Shift from folk to ethnic culture as Eastern European Jews emigrated to North America in the 20th century. Nature of tradition and ethnicity; difference made by gender in experiencing traditional culture; relationship between "official" religion and popular traditions. Readings supplemented by films, field trips, and student field work. Weissler

Anth 140. (CogS 140, Psyc 140, MFL 140) Introduction to Descriptive Linguistics (3)

Relationship between language and mind; formal properties of language; language and society; how languages change over time.

Anth 142. (Rel 142) Prehistoric Religion and Technology (3)

Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot

Anth 151. Utopias and Alternative Communities (3)

Present and past searches for new forms of community in fact and fiction. Frankel

Anth 174. (Clss 174, Art 174, Arch 174) Greek Archaeology (3)

Ancient Greek culture from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small

Anth 176. (Clss 176, Art 174, Arch 176) Roman Archaeology (3)

Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small

Anth 178. (Clss 178) Mesoamerican Archaeology (3)

Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructions of urban centers, political and economic organizations, and theories of the Mayan collapse. Small

Anth 180. (Clss 180) Cultures of the Greeks and Romans (3)

Analysis of Greek and Roman Cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature, and warfare. Small

Anth 182. North American Indians (3)

Culture areas of native North America prior to substantial disruption by European influences north of Mexico. Environmental factors and cultural forms. Gatewood

Anth 184. Cultures of the Pacific (3)

Cultures of the Pacific Islanders prior to substantial disruption by European influences. Culture histories, language families, social organizations, and religions of Australian, Melanesian, Polynesian, and Micronesian peoples. Gatewood

Anth 186. Peoples of Island Southeast Asia (3)

Peoples and cultures of Malaysia, Singapore, Indonesia, Brunei, and the Philippines. Religions, world views, economies, and political forms. Tannenbaum

Anth 188. Peoples of Mainland Southeast Asia (3)

Peoples and cultures of Burma, Laos, Cambodia, and Thailand. Religions, world views, economies, and political forms. Tannenbaum

Anth 305. Anthropology of Fishing (3)

Comparative study of fishing peoples and their technologies. Fishing strategies, control of information, and social organization of marine exploitation in subsistence and modern industrial contexts. Theory of common-property resources and the role of social science in commercial fisheries management. Gatewood

Anth 321. Anthropology of Physical and Mental Health (3)

Definition and treatment of physical and mental health in cross-cultural perspective. Strategies for coping with illness in literate and nonliterate, Western and non-Western societies. Frankel

Anth 325. Economic Anthropology (3)

Cross-cultural perspectives on the ways people produce, distribute, and consume goods; how these systems are organized; and how they are connected with other aspects of society, particularly political and ideological systems. Tannenbaum

Anth 335. (Rel 335) Religion, Symbolism and Cosmology (3)

How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel

Anth 339. Seminar in Anthropology (3)

Topics in anthropology. Varying semester to semester: human evolution, politics and law, introduction to linguistics, human use of space, anthropology of deviance. May be repeated for credit.

Anth 345. (Clss 345) Evolution of the State (3)

Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and New World. Small

Anth 363. Kinship, Marriage and Descent (3)

Kinship as the central institution in primitive social organization. Variations in definition and regulation of marriage and descent in cross-cultural perspectives. Critiques of Murdock, Levi-Strauss, and Fortes. SSP 364 recommended in conjunction with this course. Gatewood

Anth 371. Special Topics (1-3)

Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson.

Anth 376. Mind, Self and Culture (3)

Concepts and methods of studying relations between the individual and the sociocultural milieu. Culture and personality language and thought, cross-cultural studies of cognition. Gatewood

Anth 393. Research Apprenticeship (3-4)

Conducting anthropological research under the supervision of a faculty member. May be repeated for credit.
Prerequisite: consent of the department chairperson.

Anth 399. Senior Thesis (3)

Research during senior year culminating in senior thesis. Required for anthropology majors seeking departmental honors. Prerequisites: consent of the department chairperson.

Sociology/Social Psychology**SSP 5. Introductory Sociology (3) fall**

Social organization, stability and conflict, structure and function, and processes of social change in society.

SSP 21. (Psyc 21) Social Psychology (3) spring

Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior and social interaction.

SSP 100. Seminar in Sociology and Social Psychology (1-4)

Topics in sociology and social psychology. May be repeated for credit.

SSP 103. (AAS 103) Race Relations (3)

Racism, discrimination and prejudice, racial and ethnic conflict, and racial oppression in American society. Efforts by racial groups to improve their social conditions, e.g., the Civil Rights Movement. Focus on problems faced by Blacks, Hispanics, Native Americans, and Asians in contemporary United States. Thomas

SSP 109. (Psyc 109) Adulthood and Aging: (3) fall

Social science approaches to the latter two-thirds of the life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: Psyc 1 or SSP 21 or consent of instructor. Hyland

SSP 125. (Psyc 125) Social Psychology of Small Groups (3)

Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein

SSP 135. (Jour 135, Psyc 135) Human Communication (3)

Processes and functions of human communication in relationships and groups. Rosenwein

SSP 141. Social Deviance Social Control (3)

Analysis of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh

SSP 152. Alcohol, Science and Society (3)

Alcohol use and abuse, its historical function in society, moral entrepreneurship, status struggles and conflict over alcohol. Current problems with attention to special population groups and strategies for prevention of alcohol abuse. McIntosh

SSP 153. (Psyc 153) Personality (3)

Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1 or SSP/Psyc 21.

SSP 160. Medicine and Society (3)

Health, illness, and the health professions from the sociological perspective. Social epidemiology, social psychology of illness, socialization of health professionals, organization of health care, patient-professional relationships and ethical issues in medical care. Lasker

SSP 162. AIDS and Society (3)

Impact of the AIDS epidemic on individuals and on social institutions (medicine, religion, education, politics, etc.); social and health policy responses; international experience;

effect of public attitudes and policy on people affected directly by AIDS. Lasker

SSP 165. Contemporary Social Problems (3)

Studies of major problems facing contemporary society.

SSP 308. (Psyc 308) Seminar in Social Psychology (3)

Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit.

SSP 312. (Psyc 312) Interpersonal Behavior in Small Groups (3)

Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Rosenwein

SSP 314. (Psyc 314) Attitudes, Attributions, and Actions (3)

Social perception and cognition as studies in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change.

SSP 323. (Psyc 323) The Child in Family and Society (3)

Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. Herrenkohl

SSP 325. (Hist 325) American Social History, 1607-1877 (3) fall

Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade

SSP 326. (Hist 326) American Social History Since 1877 (3) spring

Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Prerequisite: any one of the following: Hist 10, 137, 138, or 139, or consent of history department chair. Simon

SSP 327. (Jour 327) Mass Communication and Society (3)

A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Rosenwein

SSP 333. (Govt 333, Psyc 333) Social Psychology of Politics (3)

Political behavior viewed from a psychological and social psychological perspective. Rosenwein

SSP 341. (WS 341) Women and Health (3)

Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Lasker

SSP 351. (WS 351) Gender and Social Change (3)

Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Spade

SSP 355. Sociology of Education (3)

Education as a social institution. Statuses, roles, and relationships in the organization of schools; higher education as well as elementary and secondary schools. Spade

SSP 356. (Psyc 356) Seminar in Personality Psychology (3)

Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment.

Prerequisite: SSP/Psyc 153 or consent of instructor.
Williams, Wurf

SSP 359. Sociology of Religion (3)

Religion as a central institution in society. Social functions provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Thomas

SSP 361. (Psyc 361) Personality and Social Development in Adulthood (3)

Theories and current research. Prerequisite: SSP/Psyc 109 or consent of Psychology department chair. Hyland

SSP 363. (Psyc 363) Personality and Social Development in Childhood (3)

Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: Psyc 107 or 108 or SSP/Psyc 109 or consent of instructor. Phillips

SSP 364. (WS 364) Sociology of the Family (3)

Historical development of families in the U.S. and issues faced by contemporary American families, including parenting, combining work and family, and divorce and remarriage. Anth 363 recommended in conjunction with this course. Spade

SSP 366. Sociology for Aging (3)

Residential patterns, social policies and services for the aged. Alternative political strategies, health programs, living arrangements and workplace choices considered. The changing roles of the elderly in American and other societies, and the special problems they face. Impact of changing age structure. Lasker

SSP 370. Juvenile Delinquency (3)

The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. Bell

SSP 371. Special Topics (1-3)

Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chairperson.

SSP 373. Seminar in Sociology (3)

Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit.

SSP 374. Social Stratification (3)

Social inequality as an organizing principle in complex societies. Theories of wealth, class, and power. Sociological impact of education, occupation, and income on social status and social class.

SSP 379. (AAS 379) Race and Class in America (3)

The nature of race and class in America and how these two organizing principles affect the lives of African Americans and other racial minorities. Issues related to the "race versus class" debate, with special attention to differences between the Black under-class and Black middle-class. Thomas.

SSP 391. (Psyc 391) Evaluation Research (3)

Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or SR 112 or consent of department chairperson. Herrenkohl

SSP 393. Research Apprenticeship (3-4)

Conducting sociological or social psychological research under the supervision of a faculty member. May be repeated

for credit. Prerequisite: consent of the department chairperson.

SSP 399. Senior Thesis (3)

Research during senior year culminating in senior thesis. Required for sociology/social psychology majors seeking departmental honors. Prerequisites: declared major in sociology/social psychology and consent of the department chairperson.

For Graduate Students

The department offers a master's (MA) degree program in social relations. This thirty-credit program provides further preparation for an advanced degree and training for nonacademic careers. Students may concentrate in (1) health, family, and human development, (2) human ecology and social structure, (3) analysis of interaction processes, or (4) a program tailored to individual educational needs. All graduate students complete the program with a thesis. In conjunction with the Center for Social Research the department offers many opportunities for research experience. For further information students should contact the department chair or graduate program director.

SR 401. Proseminar in Applied Social Research

Specialized topics including advanced statistical and measurement techniques, computing methods, data base management, research design and specialized areas of research activity. Can be repeated for credit. Permission of instructor required.

SR 411. Advanced Research Methods (3) fall

A basic course given in research theory and methods. Consideration given to the nature of theory, hypotheses testing, the definition of variables and methods of measurement.

SR 412. Practicum in Research Methods (3) spring

Laboratory in the design and execution of research. Includes class project. Prerequisite: SR 411.

SR 413. Fieldwork in Social Relations (3)

Supervised work experience in a variety of field settings, e.g., hospital, public and private social service agencies and organizations.

SR 414. Survey Research (3)

Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SR 416. (Educ 416) Quasi-Experimentation and Program Evaluation (3) spring

Social science methods for non-laboratory settings. Examination of quasi-experimental research designs, threats to validity, possible controls, and uses in social program evaluation. Non-mathematical presentation. Knowledge of elementary statistics assumed. Campbell

SR 461. Seminar in Social Relations (1-4)

Topics in social relations: anthropology, sociology and social psychology. Topics vary.

SR 470. Social Theory (3) fall

Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

SR 471. Special Topics (1-3)

Intensive study in an area of social relations that is appropriate to the interests and needs of staff and students.

SR 472. Special Topics (1-3)

Continuation of SR 471.

SR 473. (Educ 473) Social Bases of Human Behavior (3)

Development of human behavior from a social psychological

perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

SR 477. Advanced Computer Applications (4) spring
Uses of computers in social sciences, including data collection, management, and analysis, simulations, and decision-making; includes weekly lab.

Spanish

See listings under Modern Foreign Languages.

Special Education

See listings under Education.

Speech

See listings as Communication under Journalism and Communication.

Technology, Interdisciplinary Courses

See listings under Science, Technology and Society.

Theatre

Professor. Jeffrey Milet, M.F.A. (Yale).

Associate professor. Augustine Ripa, M.F.A. (Northwestern) Chairman.

Assistant professor. Pam Pepper, M.F.A. (Ohio).

Visiting assistant professor. Alexander Brietzke, M.F.A. (Alabama), Ph.D. (Stanford).

Adjunct assistant professor. Andrea Roney, M.F.A. (Penn State).

Adjunct instructors. Eric Beatty, Susan Chase, Jenny Gilrain, Mark McKenna (Touchstone Theatre).

Resident designer. Vicki Neal, M.F.A. (S.I.U.).

Business manager. Allison Q. Blatt, B.A. (Concord).

To study theatre is to examine its many internal disciplines. Acting and directing combine with design, technical theatre, dramatic literature and theatre history to form the body of our art. Students may pursue general theatre studies or focus on particular areas such as performance or design. They may major in theatre, minor in theatre or participate strictly in our production program. Students may even complete a minor in theatre from outside the College of Arts and Science.

The bachelor of arts degree in theatre is granted after at least thirty one credit hours of study. Because we believe that undergraduate theatre education should be broad based with an emphasis on diversity of experience, students are encouraged to take a variety of courses outside the major. Some students complete double majors. Those with the talents and aspirations for a career in theatre have gone to graduate schools offering intense, pre-professional training. Recent majors who have not pursued a theatrical career have gone from our program directly into careers in business, social services, sales. Theatre study is an excellent preparation for vocations in which self presentation is important, such as law. The problem solving, analytical and

interpersonal skills gained from this discipline are applicable across a wide range of careers. An understanding and appreciation of the complex art of the theatre will enrich a lifetime.

In addition to its academic courses, the department sponsors an active production program in which students, faculty and guest artists collaborate. Our main performance facility is the Wilbur Drama Workshop, a large, classic black box theatre. The core of our work in this space is dedicated to productions featuring primarily student actors directed by faculty or guest artists. When possible, a highly qualified student may direct or design in the main space. In addition to our own productions, we regularly invite outside professional performers and ensembles to work with us and perform. We also operate a separate lab theatre designed specifically for student experimentation. The availability of valuable hands-on experience and the very close working relationships developed between students and faculty uniquely characterize the department of theatre.

Students interested in designing a major or minor in theatre should consult with the department chairperson. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the chairperson.

The department of theatre is accredited by the National Association of Schools of Theatre.

Theatre Major

Through the selection of appropriate electives, students may concentrate their major in one of these areas:

ACTING/DIRECTING
DESIGN/TECHNICAL THEATRE
GENERAL THEATRE STUDIES

The major in theatre consists of 39 hours distributed as follows:

Coursework required of all majors, 24 hrs

Thtr 61	Theatre Production (8) (see production requirement)
Thtr 117	Theatre History (3)
Thtr 123	Dramatic Literature (3)
Thtr	Acting (3) any appropriate level
Thtr	Design (3) scenic, lighting or costume
Thtr 144	Basic Directing (3)
Thtr 315	Senior Study (1)

Electives, 15 hrs

Through the careful selection of theatre electives a student may emphasize acting/directing, design/technical theatre or general theatre studies.

Recommended electives from other departments:

The departments of Art and Architecture, Classics, English, Modern Foreign Languages, Music and others all offer courses of value to a theatre major or minor. Consult with your advisor about scheduling these.

Theatre Minor

The minor in theatre consists of 19 credit hours selected in consultation with a departmental advisor. This includes 4 credits of Theatre Production or equivalent. See Production Requirement. Through the careful choice of courses students may create emphases in Acting/Directing, Design/Technical Theatre, or General Theatre Studies.

The Production Requirement

A theatre major is required to complete four ACTIVE SEMESTERS of production activity to complete the major. An ACTIVE SEMESTER is defined as a semester in which the student completes at least TWO CREDIT HOURS of approved coursework relating to Lehigh University Theatre productions. This may be accomplished a number of ways, including by taking Theatre 61, Theatre Production (2 hrs). This example is provided above in the section describing

coursework required of all majors. Students completing Theatre 61, Theatre Production, for ONE CREDIT HOUR will complete ONE-HALF of an ACTIVE SEMESTER. Of the FOUR ACTIVE SEMESTERS required of the major, at least TWO must be completed in the junior or senior year. A student may complete ACTIVE SEMESTERS through other courses such as Theatre 185, Production Seminar (3), or Theatre 351, Advanced Special Projects (1-6). Of the FOUR ACTIVE SEMESTERS required, at least ONE ACTIVE SEMESTER must be awarded for off-stage activity. Majors should consult with the department every semester regarding APPROVED COURSEWORK for an ACTIVE SEMESTER of production activity.

Minors are required to complete TWO ACTIVE SEMESTERS of production activity.

Departmental Honors

The exceptional theatre student may elect to pursue departmental honors in the senior year. This student must have a gpa of 3.3 in all theatre courses presented for the major. In the fall of the senior year the student, with faculty supervision, elects a special project in a particular area of theatre. This may take the form of preparing to direct a play, researching a role to be performed, preparing a design presentation or researching in an area of theatre scholarship in preparation for the writing of a substantial report. In the spring of that year the report or project would be executed. The student will enroll in two three credit honors courses, each senior semester.

The Acting Sequence

Students with little or no prior acting experience should elect Theatre 11, Introduction to Acting, as their first course. Students with some prior acting experience should consult with the department chairperson for accurate placement and waiver of the Theatre 11 prerequisite.

Courses in Theatre

Thtr 1. Introduction to Theatre (3)

Foundations of theatre: historical, literary and practical.

Thtr 11. Introduction to Acting (3)

Discussion of text. Basic exercises and techniques. Preparation for scene study. Recommended for students with little or no prior experience.

Thtr 15. Introduction to Design and Technical Theatre (3)

Theatrical materials and methods. Basic concepts in scene design and stage lighting. Supervised practical experience.

Thtr 61. Theatre Production (1-2)

Supervised practical experience in theatrical production. May be repeated for credit. Prerequisite: consent of chairperson.

Thtr 111. Theatre Sound (1)

Techniques, materials, and methods of designing sound for theatrical production.

Thtr 113. Stage Lighting (3)

An introduction to the art and practice of lighting for the stage.

Thtr 115. Scene Design (3)

An introduction to the art of the scenic designer. History of design for the theatre. Materials, methods and techniques.

Thtr 116. Stagecraft (3)

Drafting, problem solving, stagecraft, rigging, materials and techniques. The role of the technical director.

Thtr 117. Theatre History (3)

Historical survey of western theatre from origins to present.

Thtr 123. Dramatic Literature (3)

Western dramatic literature. Emphasis on major authors, genres, periods.

Thtr 144. Basic Directing (3)

Introduction to the theatrical director's art. Scene work. Prerequisites: Thtr 117 or 123 and acting experience as determined by the department, or consent of chairperson.

Thtr 147. Acting Early Modern Drama (3)

Elements of characterization through scene study. Emphasis on work of early modern dramatists, e.g. Ibsen, Strindberg, Chekhov and others. Prerequisite: Thtr 11 or consent of chairperson.

Thtr 148. Acting Modern American Drama (3)

Elements of characterization through scene study. Emphasis on works of recent dramatists, e.g. O'Neill, Williams, Miller and others. Prerequisite: Thtr 11 or consent of chairperson.

Thtr 151. Costume Design (3)

The history and development of theatrical costuming. Wardrobe and its relationship to art and culture.

Thtr 161. Theatre Design and Technology (3)

Theatre environments, equipment systems and acoustics. Functions and ethics.

Thtr 175. Special Projects (3)

Theatrical topics of current or special interest, e.g., mime. Can be repeated for credit as title varies.

Thtr 181. Theatre Management (3)

Concepts, techniques and practices related to managing the theatrical enterprise.

Thtr 185. Production Seminar (1-3)

Practicum in various approaches to theatre production, e.g. ensemble. Prerequisite: consent of the chairperson. Can be repeated for credit as title varies.

Thtr 214. Advanced Lighting (3)

Continuation of Theatre 113. Lighting design for various performance forms. Practical experience. Prerequisite: Thtr 113.

Thtr 216. Advanced Scene Design (3)

Continuation of Theatre 115. Advanced design problems and techniques. Practical experience. Prerequisite: Thtr 115.

Thtr 244. Acting Styles (3)

Acting problems in non-realistic drama, e.g. Shakespeare. Prerequisite: a 100-level acting course, or consent of chairperson.

Thtr 245. Advanced Directing (3)

Continuation of Theatre 144. Directorial approach. Supervised practical experience. Prerequisite: Thtr 144.

Thtr 271. Playwriting (3)

Techniques of the dramatist. The playwright's creative process. Practice in creating dramatic forms.

Thtr 275. Internship (1-3)

Professionally supervised work in theatres and theatrical organizations in the areas of performance, design, technical theatre, theatre administration and management. May be repeated for credit. Prerequisite: consent of chairperson.

Thtr 315. Senior Study (1)

Seminar for senior theatre majors. Enhancement of current theatre studies while preparing for further theatre studies or activity. Fall only.

Thtr 351. Advanced Special Projects (1-6)

Independent study in theatre. Prerequisite: consent of the chairperson. Can be repeated for credit as title varies.

Thtr 361. Research in Theatre Technology (1-3)

Solving technological problems in theatre. Application of new technologies. May be repeated for credit. Prerequisite: consent of chairperson.

Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr., M.A. (Penn State), *lecturer in urban studies and director of urban studies*; Frank T. Colon, Ph.D. (Pittsburgh), *professor of government*; Barbara Frankel, Ph.D. (Princeton), *professor of social relations*; Warren A. Pillsbury, Ph.D. (Virginia), *associate professor of economics*; Roger D. Simon, Ph.D. (Wisconsin), *professor and chairman of history*; J. Bruce Thomas, Ph.D. (Berkeley), *assistant professor of architecture*; Ivan Zaknic, M.Arch. and Urban Planning (Princeton), *associate professor and chairman of architecture*.

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as business or law, and such specialized areas as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, the relationship between cities and economic growth, and existing and proposed public policies relating to cities.

A minimum of 33 credit hours is required, apportioned among two levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. The director's office is located at 232 Chandler-Ullmann Hall.

Undergraduate Major

I. required preliminary courses (9 credit hours)

US 61	The Study of Urbanization (3)
US 62	Contemporary Urban Issues (3)

one of the following research methods courses

Govt 321	Research in Political Science (3)
Eco 145	Statistical Methods (3)
Hist 202	Introduction to Historical Research (3)
Math 12	Statistical Methods (3)
SR 111	Research Methods of Social Relations (4)

II. elective courses (24 credit hours)

Any course may be elected from among the following:

Anth 128	Urban Ethnology (3)
Anth 151	Utopias and Alternative Communities (3)
Eco 312	Urban Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Govt 177	Urban Politics (3)
Govt 360	Public Administration (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
Soc 370	Juvenile Delinquency (3)
US 363	Philadelphia: Development of a Metropolis (3)

Up to two Architectural History courses numbered 197 or higher

Up to two courses may be elected from among the following:

Eco 354	Public Finance: State and Local (3)
Govt 331	Government and Law Internship (3) (Govt 332 may be offered instead of Govt 331)
Hist 326	American Social History Since 1877 (3)
US 125	American Ethnic Groups (3) (US 321, 324, 326 or 328 may be offered instead of US 125)
US 371/372	Special Topics (3-6)

Any Architectural History course not counted above

Participants in off-campus programs, such as the Philadelphia or Washington semesters, may receive credit for up to three elective courses, depending upon the content of those courses, but they must also complete at least five courses in the first group of electives above.

Urban studies minor. The minor consists of US 61 and five additional courses from an approved list for a total of eighteen credit hours.

Undergraduate Courses

61. The Study of Urbanization (3) fall, 1993 & 1995

Introduction to the study of cities. Emphasis on sources of economic vitality, especially entrepreneurialism, and on urban sociology. Some lectures on Bethlehem and Lehigh Valley history for illustrative purposes. Amidon

62. Contemporary Urban Issues (3) spring, 1995

Analysis of problems, typically including planning, housing, and finance, with strong emphasis on twentieth-century New York City. Amidon

125. American Ethnic Groups (3) spring, 1994

Immigration to the United States; persistence of cultural differences over generations; patterns of conflict and accommodation; assimilation; ethnic politics; emphasis on white Euro-American nationality groups; with some attention to Afro-, Hispano-, Asian-, and native Americans. Amidon

321. White Protestant Americans (3) spring, 1995

Cultural and religious origins of the historically dominant ethnic group in the United States; rise and decline of national Anglo-Protestant urban elite; persistence of regional and nonelite subcultures; "Wasp" stereotypes and anti-Protestant themes in American culture. Amidon

324. The Irish in American Society (3) spring, 1996

Cultural, economic and political experience of a major white ethnic group in the United States; Irish Catholics vs. Scotch-Irish Protestants; immigrant poverty; priests and prelates, ward healers and big-city bosses; Irish themes in American literature, humor, and media culture; Irish radicalism. Amidon

326. The American Italian Community (3) spring, 1997

European background of Italian emigration; patterns of first-generation experience in the United States; distinctive values, folkways, and institutions; the "Mafia"; political behavior; upward mobility and assimilation; achievements of outstanding individuals; interaction with general American culture. Amidon

328. The American Jewish Community (3) spring, 1994

Historical and sociological perspectives on the experience of an important minority in the United States; communal institutions and social patterns; orientation toward achievement and secular success; Jewish influences in American culture; anti-Semitism, acceptance, and survival as a distinct subculture. Amidon

363. Philadelphia: Development of a Metropolis (3) fall, 1994

Philadelphia as an early experiment in the deliberate creation of a new community; the rise of the port; industrialization and immigration; creation of a hinterland and competition with rival centers; upper-class family continuity; religious life and institutions; political history. Amidon

371, 372. Special Topics (3-6)

A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director.

Women's Studies

Lucy C. Gans, M.F.A. (Pratt), *Director of Women's Studies program and associate professor of art.*

Professors. Rosemarie Arbur, Ph.D. (Illinois), *professor of English*; Elizabeth E. Filer, Ph.D. (Michigan), *professor of English*; Judith N. Lasker, Ph.D. (Harvard), *professor of Sociology and Anthropology*; Ralph Lindgren, Ph.D. (Marquette), *Clara H. Stewardson Professor of Philosophy*; Laura K. Olson, Ph.D. (Colorado), *professor of Government*; C. Robert Phillips, Ph.D. (Brown), *professor of History*; William G. Shade, Ph.D. (Wayne State), *professor of History*; Laurence J. Silberstein, Ph.D. (Brandeis), *Phillip & Muriel Berman Professor of Jewish Studies, professor of Religion Studies and Director, L.V. Center for Jewish Studies.*

Associate professors. Robin S. Dillon, Ph.D. (Pittsburgh), *associate professor of Philosophy*; Diane T. Hyland, Ph.D. (Syracuse), *associate professor of Psychology and Director, Center for Social Research*; Lenore E. Weissler, Ph.D. (Pennsylvania), *chairperson & associate professor of Religion Studies & Philip and Muriel Berman Chair of Jewish Civilization.*

Assistant professors. Gail A. Cooper, Ph.D. (California-Santa Barbara), *assistant professor of History*; Jill E. Schneider, Ph.D. (Wesleyan), *assistant professor of Psychology*; Joan Z. Spade, Ph.D. (SUNY-Buffalo), *assistant professor of Sociology and Anthropology*; Nicola B. Tannenbaum, Ph.D. (Iowa), *assistant professor, Sociology and Anthropology*; Elissa D. Wurf, Ph.D. (University of Michigan-Ann Arbor), *assistant professor, Psychology.*

The minor in Women's Studies engages students in the study of two interrelated subjects. The first is an examination of the cultural, historical, and social experiences and contributions of women. The second is an exploration of gender (i.e., the social construction of differential identity for males and females) and of the many ways in which gender distinctions have shaped human consciousness and human society.

Nearly all academic disciplines have defined human nature and significant achievement in terms of male experience and have underestimated the impact of gender on social structures and human lives. By contrast, Women's Studies courses attend to women's diverse experiences and perspectives and acknowledge the critical significance of gender. By shifting the focus onto women and gender, Women's Studies seeks to provide an alternative paradigm for understanding human experience. Students in Women's Studies courses are encouraged to reevaluate traditional assumptions about human beings, human knowledge, and human culture and society, and to explore non-sexist alternatives for a more fully human social order.

The Women's Studies Program has several major goals: to expand students' understanding of women's present status and rich history; to stimulate a critical examination of the impact of gender roles and stereotypes on social structures and individual lives; to evaluate proposals for alternative arrangements; and to connect issues addressed in the classroom with those raised in personal, political, and cultural contexts. The program challenges students to think beyond the boundaries of traditional gender roles, traditional disciplines, and established institutions. In the best tradition of a liberal arts education, Women's Studies encourages women and men to think critically and constructively, to redesign knowledge, and to gain a better understanding of themselves and their world.

The minor in Women's Studies consists of a minimum of 18 credit hours (6 courses). Students pursuing the minor are required to take the introductory course (WS 101) and one upper-level course from among those concerned with the theory and practice of Women's Studies. The remaining 4 courses must include at least one course in the arts and humanities and one course in the natural and social sciences. Students arrange their program in consultation with the Program Director, Professor Lucy Gans, Department of Art and Architecture.

In addition to the following, new courses may be offered

annually. Students should check with the Director for an updated list.

Required courses (6 credit hours)

WS 101	Introduction to Women's Studies (3) and
WS 350	Senior Seminar (3) or
WS 271	Independent Reading and Research (1-3) or
WS 330	Internship in Women's Studies (3)

Elective Courses (12 credit hours)

SR 41	Human Sexuality (3)
Art 121	Women in Art (3)
Anthr 123	Cultural Construction of Gender (3)
Hist 124	Women in America (3)
Phil 126	Feminism and Philosophy (3)
Psych 131	Psychology of Women (3)
Clss 152	Women in Antiquity (3)
Rel 138	Women in Jewish History (3)
Rel 158	Sex and Gender in Judaism: The Feminist Critique (3)
Govt 179	Politics of Women (3)
Rel 184	Religion, Gender and Power (3)
Phil 221	Sex Discrimination and the Law (3)
WS 272	Special Topics in Women's Studies (3)
Engl 311	Literature of Women (3)
Hist 325	American Social History 1607-1872 (3)
Hist 326	American Social History Since 1877 (3)
Soc 341	Women and Health (3)
Soc 351	Gender and Social Change (3)
Soc 364	Sociology and the Family (3)

Undergraduate Courses in Women's Studies

Description of Required Courses (6 credit hours)

WS 101. Introduction to Women's Studies (3)

Placing women's experience at the center of analysis, the course will introduce students to the key concepts, theoretical frameworks, and interdisciplinary research in the new scholarship on women. Examines how gender interacts with race, age, and class to shape human consciousness and determine the social organization of human society.

WS 271. Independent Reading and Research (1-3)

Independent study of selected topics designated and executed in close collaboration with member of Women's Studies faculty. Students taking this course as a requirement for the minor must elect the three-credit option. Prerequisite: consent of program director.

WS 330. Internship in Women's Studies (3)

Supervised work in women's organizations or settings, combined with an analysis, in the form of a major paper, of the experience using the critical perspectives gained in Women's Studies courses. Placements arranged to suit individual interests and career goals; can include social service agencies, women's advocacy groups, political organizations, etc. May be repeated for credit. Prerequisite: WS 101 and permission of program director.

WS 350. Senior Seminar (3)

An upper-level seminar that challenges students to systematize insights gained from introductory and elective courses by applying the interdisciplinary methodology of Women's Studies to a focused topic. Subject matter varies semester to semester. Offered by Women's Studies faculty on a rotating basis. May be repeated for elective credit. Prerequisite: WS 101, or permission of program director.

Undergraduate Elective Courses in Women's Studies

Description of Elective Courses (12 credit hours)

WS 41. (SR 41) Human Sexuality (3)

Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior.

WS 121. (Art 121) Women in Art (3)

Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in art world. Visits to museums and artists' studios. May be repeated for credit, as topic varies. Gans

WS 123. (Anthr 123) Cultural Construction of Gender (3)

Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum

WS 124. (Hist 124) Women in America (3)

Roles of women in American society from colonial to present times; attitudes toward women, female sexuality, women's work, and feminism. Shade

WS 126. (Phil 126) Feminism and Philosophy (3)

Analysis of the nature, sources and consequences of the oppression and exploitation of women, and justification of strategies for liberation. Topics include women's nature and human nature, sex roles and gender differences, sexism, femininity, sexuality, reproduction, mothering. Dillon

WS 131. (Psych 131) Psychology of Women (3) fall

Biological, cross-cultural, sociological and psychological perspectives on women, with reference to personal experience where appropriate. Prerequisite: Psyc 1 or an introductory social relations course. Hyland, Wurf, Schneider

WS 138. (Rel 138) Women in Jewish History (3)

Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler.

WS 152. (Clss 152) Women in Antiquity (3)

Interdisciplinary study of women in Greece and Rome. Literary archaeological and historical evidence and approaches. Cross-cultural material.

WS 158. (Rel 158) Sex and Gender in Judaism: The Feminist Critique (3)

Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God and God language, communal power, and marriage and divorce. Silberstein

WS 179. (Govt 179) Politics of Women (3)

Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson

WS 184. (Rel 184) Religion, Gender and Power (3)

Gender differences as one of the basic legitimations for the

unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberstein

WS 221. (Phil 221) Sex Discrimination and the Law (3)

A critical study of the law of sex-discrimination in areas of constitutional law, labor law, education law, family law and criminal law. A case approach that covers such topics as equal protection, equal educational and employment opportunity, reproductive rights, sexual violence and affirmative action. Lindgren

WS 272. Special Topics (3)

Intensive study in areas appropriate to interests and needs of students and staff. May be cross-listed with relevant offerings in major departments of other programs. May be repeated for credit. Prerequisite: permission of program director.

WS 311. (Engl 311) Literature of Women (3)

Women's works about women: is literary creativity gender-identified? Are there specifically "feminine" subjects or themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works by less famous writers. Arbur

WS 325. (Hist 325) American Social History 1607-1872 (3) fall

Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Prerequisite: Any one of the following: Hist 9, or 119, or 120, or 135. Shade

WS 326. (Hist 326) American Social History Since 1877 (3) spring

Changing role of women, minorities, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Prerequisite: Any one of the following: Hist 10, or 137, or 138, or 139. Simon

WS 341. (Soc 341) Women and Health (3)

Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Lasker

WS 351. (Soc 351) Gender and Social Change (3)

Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Spade

WS 364. (Soc 364) Sociology of the Family (3)

Historical development of families in the U.S. and issues faced by contemporary American families, including parenting, combining work and family, and divorce and remarriage. Anth 363 recommended in conjunction with this course. Spade



VI.

An Overview from Past to Present

Lehigh University is independent, nondenominational, and coeducational.

Founded in 1865 as a predominantly technical four-year school, the university now has approximately 4,500 undergraduates within its three major units—the College of Arts and Science, the College of Business and Economics, and the College of Engineering and Applied Science—and approximately 1,900 students enrolled in graduate programs offered through the Graduate School in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than forty foreign nations.

The university is primarily situated on the Asa Packer campus on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. Sayre Park, the wooded refuge located toward the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads. Many residential units on campus command a panoramic view of the Lehigh Valley. The Appalachians are visible to the west, with an especially good view from The Lookout on the Packer Campus. Both the tower and dining room in Building A on the new Mountaintop campus afford panoramic views of the Lehigh Valley. The campus at its highest point is 971 feet above sea level.

Because of the unique setting, interesting architectural treatments are possible. Several dwellings and academic buildings are entered from upper levels, such as the third floor.

A substantial portion of the upper level of Lehigh's Campus is maintained as a nature preserve. The preserve supports deer, squirrels, chipmunks, raccoons, and birds.

Besides the Asa Packer Campus, the university has extensive athletic fields and facilities on the Murray H. Goodman Campus, two miles to the south in the Saucon Valley. The university acquired the Mountaintop Campus at the end of 1986. It links the Asa Packer and Murray H. Goodman campuses and brings total land holdings in Bethlehem to 1,600 acres, nearly double the former total.

The university also operates Stone Harbor Marine Laboratory, near Stone Harbor, N.J. The institute has laboratories and dormitory space for students. It is concerned with the preservation and improvement of the coastal environment.

The board of trustees and university officers have established and enforce policies designed to preserve Lehigh's natural beauty. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the non-academic community.

There are approximately 400 members of the faculty, teaching a total of more than 2,000 course titles (not all of which are offered every semester). Among faculty members who are tenured and to whom the university has a permanent commitment, nearly all hold the doctorate degree (typically Ph.D. or Sc.D.).

In total, there are more than 2,000 employees of the university, making it the second-largest employer in the community.

History and Purpose

The principal author of the brief history of Lehigh University that follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native state. He received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship. He joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor emeritus of government, and lives in Oregon.

When the sound of the last cannon of the Civil War died away, statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education. They wanted to increase the number of trained scientists, engineers, and other skilled people so they could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind when founding and endowing Lehigh University.

The site that Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, a community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university's board of trustees, in 1869 described the origin of the university as follows:

"In the fall of 1864 an interview was requested of me by the Hon. Asa Packer, of Mauch Chunk (now Jim Thorpe), Pa. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

"After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he deigned to give \$500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

"Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had dreamed in his own mind in reference to it. His reply was, 'I am not much acquainted with these matters, but you are, and I want you if you will to devise a plan which I can

put into effective operation.' I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

"He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

"The first meeting of the Board of Trustees, selected by Judge Packer, met at the 'Sun Hotel,' in Bethlehem, July 27th, 1865, and began to organize the work before them."

The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. The principle carried forward an ideal of the great 17th-Century Moravian educator, John Amos Comenius. A motto taken from the works of Francis Bacon was used to summarize this principle, namely, *Homo minister et interpres naturae*—man, the servant and interpreter of nature, to use a free translation. That motto lives on at Lehigh, being an element in the university seal.

The trustees chose as first president a man whose education and habits expressed this principle, Henry Copp e. They established five schools, including a school of general literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.

Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th Century the total enrollment never exceeded several hundred students; the size has increased significantly in recent decades, along with the number of faculty members.

The trustees also insisted that Lehigh was to be nondenominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged, but the national financial crisis at the turn of the century decimated the value of the Lehigh Valley Railroad stock that Packer had given to Lehigh, which was the principal source of income.

At first the student body was entirely male. The contemporary ideological climate would permit nothing else. But around 1916, women were admitted to graduate programs. In 1971, the university opened its undergraduate program to them as well. Today men and women applicants are considered on an equal basis, and in the class that entered in 1986 more than 35 percent of the students were female.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and later a famous biographer, published a brief *History of Lehigh University*, in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts . . . Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the *Syracuse Post* in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life.'"

The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times. The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service.

Today, Lehigh University still adheres to Asa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain high quality in instructional programs. Generous support from individuals, foundations, industry, and government help Lehigh to retain high quality of education and faculty while keeping

tuition as low as possible. (Tuition covers only a part of the cost of a Lehigh education.)

Presidents of the University

The presidents of Lehigh University are described and their achievements cited in the following paragraphs. The years in parentheses are those served in the presidency.

Henry Copp e (1866-1875). Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming first president in 1866.

Much building was done on the new university campus. A Moravian church on Packer Avenue was remodeled into Christmas Hall; a house for the president was erected on campus; and Packer Hall, the university center, was built.

Coppee lectured in history, logic, rhetoric, political economy, and Shakespeare.

John McDowell Leavitt (1875-1880). Leavitt was an Episcopal clergyman who graduated from Jefferson College and taught at Kenyon College and Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were established.

Linderman Library rotunda was completed in 1877. Asa Packer died in May, 1879, and Founder's Day was held in his honor the following October.

Robert Alexander Lamberton (1880-1893). Lamberton, a graduate of Dickinson College, practiced law in Harrisburg, Pa., and was a university trustee when asked to become president. During his administration, students and the community witnessed the first Mustard and Cheese dramatic presentation.

A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built, now known as Chandler-Ullmann Hall. Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887.

Thomas Messinger Drown (1895-1904). Drown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College. In 1895 he assumed the presidency of Lehigh and was greatly interested in furthering the university's development as a technical school.

His first years were difficult ones because the Panic of 1893 decimated the university's stock holdings in the Lehigh Valley Railroad. Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. Williams Hall was completed. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.

Drown died in office in 1904. Professor William H. Chandler became acting president.

Henry Sturgis Drinker (1905-1920). Drinker, an 1871 Lehigh graduate, was the only university alumnus ever to become president. In 1907, the alumni endowment fund began, the *Lehigh Alumni Bulletin* was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker, besides being a lawyer, was a mechanical engineer and had been largely instrumental in solving the problems of constructing the two-mile-long Musconetcong Tunnel, an engineering feat that made possible a railroad line between Easton, Pa., and New York City. He started a tradition of businesslike management of university affairs.

During Drinker's years, more buildings were completed: the original section of Fritz Engineering Laboratory, Drown Hall, Coxie Mining Laboratory, Taylor Hall, Taylor Gymnasium and Field House, Taylor Stadium and Lamberton Hall. Drinker's interest in horticulture led to the planting of many rare trees and plants.

A teacher's course and business administration course were begun in 1909 and in 1918 the university was divided

into three colleges, liberal arts, business administration, and engineering—the roots of the colleges of today. Army ROTC was established in 1919.

Drinker's daughter, Catherine Drinker Bowen, went on to become a historical writer of note. Her experiences as the daughter of a Lehigh president and occupant of the President's House are recorded in *Family Portrait* (Atlantic Little-Brown).

Drinker resigned in 1920 and Natt M. Emery, vice president, served as chief executive officer until 1922.

Charles Russ Richards (1922-1935). Richards took office in 1922. During his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments, helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted as were the senior comprehensive examinations in the Arts College. The placement bureau, a public relations office, and a student health service were organized.

The Alumni Memorial Building—a memorial to the Lehigh alumni who served in World War I—and Packard Laboratory both were completed in 1925. In the same decade, a major addition to Linderman Library also was completed.

Clement C. Williams (1935-1944). Williams, a civil engineer, was president during an era of unprecedented alumni support. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ullmann building adjoining the Chandler Chemistry Laboratory, were built. Grace Hall, the first arena-type facility of any size on campus, was completed in 1940, the gift of Eugene G. Grace, an 1899 graduate, who headed the board of trustees. A Graduate School implemented the programs in the three colleges. Williams retired in 1944, and the university was without a president for approximately two years.

Martin Dewey Whitaker (1946-1960). Dr. Whitaker, who had been director of the Atomic Energy Commission Laboratory at Oak Ridge, Tenn., and had worked in developing the atomic bomb, faced the responsibility of helping the university community readjust to peacetime conditions after World War II.

During his time as president, Lehigh's assets nearly tripled; the endowment more than doubled to \$18 million. Many buildings were renovated, and the Dravo House and McClintic-Marshall House residence halls were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The Centennial development program was begun in 1959. It raised more than \$22 million for faculty salaries and construction that later included Whitaker Laboratory.

An extensive renovation and enlargement project associated with Packer Hall was undertaken in 1957, and, upon completion in 1958, the building became a university center.

Academically, during the Whitaker years 120 departments offered the master's degree and twelve the doctor of philosophy.

Whitaker died in office.

Harvey A. Neville (1961-1964). Dr. Neville was the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term as president, the first phase of the Saucon Valley athletic complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information and Computing Science was established.

Dr. Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

Deming Lewis (1964-1982). Willard Deming Lewis became president after a distinguished career as a space engineer and research administrator.

Dr. Lewis comes from a remarkable family that traces its American roots to William Lewis, an Englishman who settled in the Massachusetts Bay Colony in 1640. His great-grandfather and grandfather were presidents of the Lewis Manufacturing Co., a textile firm in Walpole, Mass. Willard Lewis, Deming's father, moved to Augusta, Ga., and eventually became owner of Riverside Mills there.

Deming was admitted to Harvard at age fifteen, but his mother thought him too young to attend. So he waited and entered Harvard at age sixteen, eventually receiving three degrees there, as well as two degrees from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics. At Harvard, Lewis worked with Ted Hunt, the father of high fidelity, writing the equations describing a stylus sliding through a warped groove.

In 1941, Lewis joined Bell Telephone Laboratories, and in 1962 he was one of four executives who initiated Bellcomm, Inc., in Washington, D.C., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, who died in 1990, holds thirty-three U.S. patents on such devices as microwave antennas and filter and digital error detection systems.

During the Lewis administration, undergraduate women were admitted in 1971, and the university's visiting committees were established in 1964. New programs included majors in natural science, biology, social relations, geological sciences, environmental science and resource management, and religion studies. Minors for engineering students in such fields as business, history, and social sciences were begun. Interdisciplinary majors such as computer engineering, computing and information science, applied mathematics, management science, American studies, and many others were instituted. Six research centers and seven institutes were established, including the Biotechnology Research Center.

The first phase of the New Century Fund capital campaign yielded \$1.1 million more than its goal of \$30 million; the second phase, which brought the campaign to a conclusion in 1985, raised more than \$100 million.

Construction included the following: Maginnes Hall; Whitaker Laboratory; Mart Science and Engineering Library; the Central Heating and Refrigeration building; Sinclair Laboratory; the Seeley G. Mudd Building and Neville Hall, Rathbone Hall dining room; thirteen fraternity houses, the Centennial I and Centennial II residential complexes; the Trembley Park student apartment complex; the Saucon Village Apartments complex, completion of the acquisition of the Saucon Valley athletic lands and the construction there of the Varsity House, the squash courts, the Philip Rauch Field House and Stabler Athletic and Convocation Center; and Brodhead House, a six-story residence hall. In addition, the restoration of Packer Memorial Church was completed, as well as a million-dollar renovation of Packard Laboratory. Plans were made for the E. W. Fairchild-Martindale Library and Computing Center.

Dr. Peter Likins (1982-present). Dr. Likins became eleventh president in 1982. Under his guidance Lehigh continues to seek balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

The Likins presidency has been characterized by achievement and action. In 1986, for example, Lehigh completed construction and implementation of its state-of-the-art telecommunications system, a \$20-million-plus project. As a result, all university buildings and residential facilities are wired to allow students and faculty maximum access to information and each other via the voice-and-data telecommunications network. Completion of the network approximately coincided with the dedication in 1985 of the E.W. Fairchild-Martindale Library and Computing Center, which affords to the campus community one of the most automated library facilities available anywhere.

In 1986, a building adjoining the campus, at 200 W. Packer Ave., was named the Harold S. Mohler Laboratory, honoring the former chairman of the board of trustees. The building has been renovated to accommodate the Lehigh programs in manufacturing systems engineering. The high-tech environment gives students access to the latest

technology in robotics. The building also houses the industrial engineering department.

In the fall of 1986, a dedication was held for the Sherman Fairchild Center for the Physical Sciences, an outstanding facility encompassing the renovated 1890s-era Physics Building, the contemporary Sherman Fairchild Laboratory, and a new structure linking the two and providing an imposing entrance to physics facilities. The new building includes a 260-seat auditorium.

Also in 1986, the university purchased research facilities and land from Bethlehem Steel Corp. to establish what is now called the Mountaintop Campus, an area southeast of the Packer Campus and north of the Murray H. Goodman Campus, that links both campuses. The acquisition of five buildings and 742 acres at a cost of \$18.75 million was the largest real estate transaction in the history of the university. Campus acreage virtually doubled.

Likins led the way in the establishment of the Colonial League, now the Patriot League, in football, effective with the 1986 season. Other schools belonging to the league are Bucknell, Colgate, Davidson, Holy Cross, Lafayette, the United States Military Academy and Fordham University. The league represents a commitment by participating schools to the principle of "scholar-athletes," students who are primarily concerned with academic work but who also play football. This principle has been a Lehigh tradition. Eventually, the member schools all will play each other every year, while also including all Ivy League schools in their schedules.

The university completed in 1989 a new stadium for football and other sports on the Murray H. Goodman Campus. Taylor Stadium has been razed to make way for the Rauch Business Center and a future center for the performing arts.

Under Likins, financial support of the university has grown from around \$10 million annually to more than \$24 million in both 1986-87. In the years 1986 through 1990, 60 percent of alumni made gifts to Lehigh, placing Lehigh just behind first-place Dartmouth and just ahead of Princeton in percentage of alumni making gifts. The three schools are the leaders among Ph.D.-granting institutions for which records are kept on a national basis.

Likins was a prime mover in the establishment in 1984 of the Lehigh Valley Center for Jewish Studies, headquartered at Lehigh and serving private colleges in the area, and the establishment of a chair in Judaica based at Lehigh supported by a major gift from Philip and Muriel Berman.

In recent years, Lehigh established a center in the field of integrated circuits, the Center for Innovation Management Studies, the Chemical Process Modeling and Control Research Center, and the Center for International Studies.

A native of California, Likins is relaxed and informal in his interpersonal dealings and has regular personal contact with undergraduates. A former collegiate wrestler of some note (in 1982 he was named to the National Wrestling Hall of Fame), he and members of his family regularly attend Lehigh athletic events.

Likins was substantially involved in the university's designation as home of the North East Tier Ben Franklin Advanced Technology Center, one of four such centers established by the Pennsylvania legislature. The North East Tier center has assisted dozens of fledgling businesses involved in high-technology fields.

Dr. Likins is a distinguished academic administrator, a seasoned educator in engineering, an expert in spacecraft dynamics and control, an author of textbooks in engineering mechanics, a researcher who continues to add to his substantial list of publications, and a consultant to governments and industry. He is one of 13 science advisors to President George Bush, serving on the president's science advisory committee.

He earned the B.S. in civil engineering from Stanford University in 1957, the master of science in civil engineering from Massachusetts Institute of Technology the following year, and the Ph.D. in engineering mechanics from Stanford in 1965. He joined Columbia as dean of the School of Engineering and Applied Science in 1976 and was named a provost in 1980. Earlier, he was a development engineer at the Jet Propulsion Laboratory of the California Institute of

Technology, and subsequently served as professor and later as associate dean of engineering at the University of California, Los Angeles. He is a fellow of the American Institute of Aeronautics and a member of the National Academy of Engineering.

Dr. Likins and his wife, Patricia, have six children and reside in the President's House.

University Campuses

Lehigh University's three campuses are located in Bethlehem, Pa., and comprise 1,600 acres.

Asa Packer Campus. Lehigh's main academic campus, encompassing approximately 360 acres on the north slope of South Mountain overlooking Bethlehem, is a wooded area where most students attend class and live. This contains the original campus of the university.

Murray H. Goodman Campus. During the 1960s, the university acquired extensive acreage in the Saucon Valley just south of South Mountain. Development of one of the nation's finest collegiate athletic complexes has continued since that time. The 500-acre campus now includes the new Murray H. Goodman Stadium (dedicated in 1988) and other athletic fields, as well as the 6,000-seat Stabler Athletic and Convocation Center, the North East Tier Ben Franklin Advanced Technology Center, the Philip Rauch Field House, and the Varsity House locker facility. The campus is named for a major benefactor, Lehigh alumnus Murray H. Goodman, of West Palm Beach, Fla.

Mountaintop Campus. Lehigh bought this campus from Bethlehem Steel Corp. in 1986. It contains 670 acres of woods and a 72-acre research site with 8 buildings, five of which are owned by the University, including a landmark tower building visible for miles around. Acquisition of the facilities—the largest single transaction in Lehigh history—connects the two older campuses. The Mountaintop Campus houses the College of Education; programs in biosciences, biochemistry, biotechnology, chemical engineering, molecular biology, ATLSS (Advanced Technology for Large Structural Systems) center, Energy Research Center, and Ben Franklin incubator companies.

Stone Harbor Marine Laboratory. Besides its Bethlehem campuses, the university also operates Stone Harbor Marine Laboratory, located on a 34-acre site adjoining a coastal salt marsh near Stone Harbor, N.J. The institute has laboratories and dormitory space for students. It is concerned with the preservation and improvement of the coastal environment. Many undergraduates study at the institute.

University Buildings

Lehigh has a major collection of 19th-century buildings designed by such prominent architects as Addison Hutton (1834-1916), Edward T. Potter (1831-1904) and the firm of Furness and Evans (Frank Furness, 1839-1912).

The university's newer structures include the Goodman Stadium (1988), the Sherman Fairchild Center for Physical Sciences (1976, 1986), the E. W. Fairchild-Martindale Library and Computing Center (1985), the Stabler Athletic and Convocation Center (1979), the Brodhead House high-rise residential facility (1979), the Seeley G. Mudd Building and Neville Hall in the chemistry complex (1975), the Philip Rauch Field House (1975), and the Rauch Business Center (1990).

Altogether, the three campuses contain 130 buildings with more than 3 million square feet of floor space.

In the following list, the first date after the name of each building indicates the year of construction. The second date indicates the year of a major addition.

Campus Landmarks

Alumni Memorial Building (1925). This edifice of Gothic design, housing admission and other administrative offices and those of the alumni association, represents a memorial to the 1,921 Lehigh alumni who served in World War I and the 46 who died. The building was designed by Theodore G. Visscher, Class of 1899, and James Lindsey Burley, 1894.

E. W. Fairchild-Martindale Library and Computing Center (1985). The high-technology building houses science and engineering holdings and a computer center. Construction was made possible by a major gift from Harry T. Martindale, a 1927 Lehigh graduate, and his wife, Elizabeth, daughter of the late Edmund W. Fairchild, founder of a business-publications and communications empire.

Linderman Library (1877). The rotunda, designed by Addison Hutton, was built as a gift to the university by founder Asa Packer as a memorial to his daughter, Lucy Packer Linderman. The rotunda is surrounded except on the south by a major addition constructed in 1929. The building houses more than 20,000 rare books and volumes related to the humanities and social science. The Bayer Galleria of Rare Books, made possible by a gift from Curtis F. Bayer, '35, was dedicated in 1985.

Packer Memorial Church (1887). The church was the gift of Mary Packer Cummings in memory of her father, founder Asa Packer. It was dedicated on Founder's Day, October 13, 1887. The building was designed by Addison Hutton; the stained-glass window over the main door is attributed to Louis Comfort Tiffany.

Observance of the centennial year took place in 1987.

President's House (1868). This 21-room residence, designed by Edward Potter, is the home of university presidents. Dr. and Mrs. Peter Likins and family have occupied the dwelling since 1982.

Packer Hall, the university center (1868). When construction of the building began in 1865, a railroad was built to transport stone to the site. The building, designed originally by Potter, was extensively renovated and enlarged in 1958.

The building was constructed at the expense of the founder, who vetoed a plan to erect it of brick. "It will be built of stone," Asa Packer responded.

Today the building houses student lounges, a student cafeteria, a snack bar, a faculty dining room, deans' offices, the journalism department, the student radio station, and a bank office and post office.

Academic and Research Facilities

Chandler-Ullmann Hall (1883, 1938, respectively). These adjoining buildings formerly were the William H. Chandler Chemistry Building (designed by Hutton) and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president, 1904 and 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department.

The department of art and architecture, division of urban studies, and department of psychology, the Environmental Studies Center, the office of Lehigh University Art Galleries and the department of theatre are located in Chandler-Ullmann.

Christmas-Saucon Hall (1865 and 1872, respectively). Christmas Hall is the university's oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with Moravian religious tradition. In 1872, Saucon Hall was constructed a few feet to the east of Christmas Hall. The buildings were connected with the construction of a "hyphen" in 1926. The building houses the department of mathematics and the office of career services.

Copp e Hall (1883). The building originally housed classrooms and a gymnasium. It is named in honor of Henry Coppee, first president. The building is partially vacant, awaiting renovations for the Department of Journalism.

Coxe Laboratory (1910). Originally a mining laboratory, the structure is named for Eckley B. Coxe, pioneer mining engineer and trustee of the university.

Drown Hall (1908). The building, designed by Furness and

Evans, is a memorial to Thomas M. Drown, president from 1895 to 1904. It is headquarters for the English Department and the Learning Center.

Fritz Engineering Laboratory (1909, 1955). The laboratory is named for John Fritz, pioneer in the steel industry in the United States and a member of the university's original board of trustees. Fritz provided funds for the original section; a seven-story addition accommodates the university's testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the largest of its kind facility currently in operation in the world. The laboratory is used primarily by the department of civil engineering.

Iacocca Hall. Known as the tower building houses The College of Education, The Chemical Engineering Department, The Molecular Biology Department, The Center for Molecular Bioscience and Biotechnology as well as a dining room and food service facilities, plus a teleconferencing classroom. There is also a library wing with offices on the mezzanine level.

Imbt Laboratories. This is primarily a high bay research lab space where the ATLSS project was constructed, and where Chemical Engineering and Energy Research Center have major research facilities. It is also the headquarters of the "Fleet of the Future" program and the Energy Research Center.

Johnson Hall (1955). The building houses the university health service, the counseling service, the chaplain's office, campus police, and the parking services office, as well as the Women's Resource Center and the Office of Continuing Education and Summer Sessions. Earle F. "Coxey" Johnson, '07, a director of General Motors Corp. and university trustee, provided funding for the structure.

Lamberton Hall (1907). The structure served as the university commons and dining room until the renovation of Packer Hall in 1958. The building honors the memory of Robert A. Lamberton, third president. It houses the music department and related organizations.

Maginnes Hall (1970). The multilevel structure is headquarters for the College of Arts and Science and also houses the departments of modern foreign languages, history, government, international relations, classics, and religion studies, as well as the Science, Technology, and Society Program, the Lehigh Valley Center for Jewish Studies, and the Center for International Studies. The university bookstore is located on the ground floor. The building is named for Albert B. Maginnes, '21, who was a lawyer and university trustee.

Mart Science and Engineering Library (1968). This structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. It operates in conjunction with the E. W. Fairchild-Martindale Library and Computing Center.

Seeley G. Mudd Building (1975). This seven-story tower houses the chemistry department. The late Seeley G. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Neville Hall (1975). This building in the chemistry complex has three auditoriums used for lectures and events. The building is named for Dr. Harvey A. Neville, president from 1961 to 1964, who was a chemist.

Newman Association Center. This Victorian structure, until the mid-1970s used as a private residence, was renovated by the Newman Association and serves as a center for students and as a residence for its director, a Roman Catholic chaplain.

Packard Laboratory (1929). The structure was the gift of James Ward Packard, Class of 1884, the electrical pioneer and inventor of the Packard automobile who served as a university trustee. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for

the College of Engineering and Applied Science. It also houses classrooms and laboratories for mechanical engineering and for electrical engineering and computer science. An auditorium accommodates large classes and various events.

Philosophy Building (1879). This small building just below Packer Memorial Church was constructed as a porter's lodge. Today it houses the philosophy department.

Price Hall. This structure formerly was a brewery named Die Alte Brauerei. In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Reese Price, president of the university board of trustees. It serves as the home of the sociology and anthropology department.

Rathbone Hall (1971). This building's upper level is a major student dining facility, with window walls affording a panoramic view of the Lehigh Valley. The building bears the name of its donor, Monroe Jackson Rathbone, '21, president of the university board of trustees from 1957 to 1973. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now Exxon Corp., and was a major innovator in the oil industry. The lower level houses the residential services office.

Rauch Business Center (1990). Lehigh's Rauch Business Center was dedicated in 1990 as the state-of-the-art home of the university's College of Business and Economics. The \$17.8-million facility has 115,000 square feet of floor space on five stories and features a diverse array of classrooms, auditoria, and conference rooms.

Sayre Building (1869). Originally known as the Sayre Observatory, the dome that once housed the telescope can still be seen. The graduate student council is headquartered here.

Sherman Fairchild Center for the Physical Sciences (1892, 1976, 1986). The center houses classrooms and laboratories for undergraduate and graduate students in physics, and also contains a new 260-seat auditorium. It consists of the original five-story stone structure built in 1892, the Sherman Fairchild Laboratory for Solid-State Studies built in 1976, and an addition built in 1985 with help from the Sherman Fairchild Foundation.

Sinclair Laboratory (1970). This facility houses the Center for Surface and Coatings Research, and other research laboratories. It is named for Francis MacDonald Sinclair, and was the gift of his widow, Jennie H. Sinclair.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin Dewey Whitaker, university president from 1946 to 1960. The building serves the department of materials science and engineering and the Materials Research Center. There are laboratories for high-pressure research and reaction kinetics, nuclear studies, analog computation, process control, high-temperature thermodynamics and kinetics, and fine structures and metallography. The Graduate School office and the office of the vice president for research are located in the building.

Williams Hall (1903). This brick structure was the gift of Edward H. Williams, Jr., Class of 1875. Dr. Williams was a professor of mining and geology. The building contains classrooms and laboratories for the departments of biology and of earth & environmental studies. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

Athletic and Convocational Facilities

Murray H. Goodman Stadium (1988). On October 1, 1988, Lehigh opened the gates to its newest athletic facility, the Murray H. Goodman Stadium, located on the Goodman Campus. Capacity is 16,000, and the stadium features a three-tiered press box, and limited chair back seating.

Grace Hall (1940). The building is named for its donor, Eugene G. Grace, Class of 1899, who was chairman of Bethlehem Steel Corp. and president of the university's

board of trustees, 1924 to 1956. The building's lower level seats 3,200 and is used for intramural sports, wrestling, and women's varsity volleyball as well as concerts and lectures. The upper level accommodates the military science and aerospace studies departments. (Scheduled for renovations as a student center).

Philip Rauch Field House (1976). Philip Rauch, '33, made a gift toward the facility. The building has 62,000 square feet of uninterrupted floor space—the equivalent of two football fields—for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track.

Sayre Field (1961). Located atop South Mountain, the field is used for intramural sports.

Stabler Athletic and Convocation Center (1979). This arena provides seating for 6,000 persons for concerts, spectator sports, and other events. University trustee Donald B. Stabler, '30, made a major financial contribution toward the facility.

Taylor Gymnasium (1913 and 1904). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, two basketball courts, a weight room/fitness center, and four racquet sport courts. The department of intercollegiate athletics is housed here.

Varsity House (1963). The building houses lockers for varsity teams. It is located on the Murray H. Goodman Campus.

Wilbur Drama Workshop (1908). During most of its life, the building served as a power plant. Renovated during the 1970s, it provides performing space for student theatrical productions.

Power Facility

Central Heating and Refrigeration (1969). This glass-walled building houses three boilers that can be fired by either oil or gas. Other equipment provides chilled water for air conditioning.

Technology Center

Ben Franklin Building (1972). Situated on the Murray H. Goodman Campus in Saucon Valley, the building houses the Lehigh-based North East Tier Ben Franklin Advanced Technology Center.

Residential Facilities

The university is primarily residential in character, with about 85 percent of undergraduates living in facilities on the campus, including university-operated residence halls and independently managed fraternity and sorority houses.

Approximately 1,850 students live in on-campus residence halls and apartments.

Residence Halls

Brodhead House (1979). This structure, the university's first high-rise residential facility, houses 200 students. The six-story building includes student suites on the five upper floors, with a dining facility and lobby on the entrance level. The building is named in memory of Albert Brodhead, a member of the Class of 1888 who died in 1933, leaving 51 Bethlehem properties to his alma mater.

Dravo House (1948). This stone edifice is the university's largest residential facility. It bears the name of two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corp., a Pittsburgh-based international construction company. Both men served as university trustees.

Drinker House (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, university president from 1905 to 1920.

McClintic-Marshall House (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and

Charles D. Marshall, both Class of 1888, who founded the McClintic-Marshall Construction Co. The firm was the world's largest independent steel fabricating firm before its acquisition by Bethlehem Steel Corp. in 1931. It built locks for the Panama Canal and constructed the Golden Gate Bridge in San Francisco Bay.

Richards House (1938). The building honors the memory of Charles Russ Richards, president of the university from 1922 to 1935. The building is constructed of stone in modified Gothic design.

Taylor Residential College (1907, 1984). The U-shaped building is one of the earliest concrete structures ever built. It was the gift of industrialist Andrew Carnegie in honor of his friend and associate, university trustee Charles L. Taylor, Class of 1876. The interior of the building was reconstructed and the exterior refinished prior to the facility becoming Lehigh's first residential college in 1984.

Trembley Park (1975). This seven-building undergraduate apartment complex is named in memory of Francis J. Trembley, Lehigh professor and pioneer ecologist.

Warren Square Complex. This cluster of four residence halls is located on Warren Square and Summit Street. They are upperclass facilities and are used as special-interest houses.

Centennial II complex (1970)

Beardslee House. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

Carothers House. Dr. Neil Carothers was dean of business.

Palmer House. Dr. Philip M. Palmer was dean of the arts.

Stevens House. The Rt. Rev. William Bacon Stevens, of Philadelphia, was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university board of trustees. He was the principal architect of the university's original academic plan.

Stoughton House. Dr. Bradley Stoughton was dean of the engineering college, 1936 to 1939.

Williams House. Dr. Clement C. Williams was president of the university, 1935 to 1944.

Saucon Village Apartments (1974)

The five-building garden apartment complex includes housing for married, graduate, and undergraduate students.

Diamond. Dr. Herbert M. Diamond, professor emeritus of economics, retired in 1964.

Gipson. Dr. Lawrence Henry Gipson, research professor of history, bequeathed his estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Dr. Gipson wrote a monumental 15-volume history, *The British Empire Before the American Revolution*. He won the Pulitzer Prize for volume 10, *The Triumphant Empire: Thunderclouds Gather in the West, 1763-1766*.

Hartman. Dr. James R. Hartman was chairman of the department of mechanical engineering and mechanics.

More. Dr. Robert P. More, '10, dean of the College of Arts and Science, who also taught German for forty years, bequeathed to the university his \$746,000 estate, amassed after investing \$3,000 in IBM stock. The university child care center is located in this building.

Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. He is a Chaucerian scholar.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872. Since the admission of undergraduate women in 1971, several sororities have come into being. Some 1,200 men live in fraternities.

Most of the fraternities have houses located in Sayre Park,

while a few others are situated off campus. All are chapters of national fraternities.

An alphabetical listing follows. The date of the founding of the chapter is given in the first column. A second year in the first column indicates reestablishment. The second column lists the date the chapter occupied its present house; any additional date indicates the most recent addition or major renovation.

Alpha Chi Rho	1918	
Alpha Sigma Phi	1929	1961
Alpha Tau Omega	1886	1966
Beta Theta Pi	1891	1968
Chi Phi	1872	1922, 1968
Chi Psi	1893	1916, 1955
Delta Chi	1952	1968
Delta Phi	1884	1963
Delta Sigma Phi	1931	
Delta Tau Delta	1874, 1985	1959
Delta Upsilon	1885	1968
Kappa Alpha	1894	1961
Kappa Sigma	1900	1973
Lambda Chi Alpha	1926	1973
Phi Delta Theta	1876	1919, 1963
Phi Gamma Delta		
Phi Sigma Kappa	1901	1957, 1970
Pi Kappa Alpha	1929	1903
Pi Lambda Phi	1915	1965
Psi Upsilon	1884	1909, 1966
Sigma Chi		
Sigma Nu	1885	1970
Sigma Phi	1887	1950, 1961
Theta Chi	1942	1964
Theta Xi	1904	1967
Zeta Psi	1973	1973

There are eight sororities. All are nationally affiliated. Six reside in the Centennial I Complex and two reside in the Sayre Park. Some 360 women live in sororities.

The sororities are listed with year of establishment at Lehigh in the first column and year of moving into their present house in the second column.

Alpha Chi Omega	1988	1989
Alpha Gamma Delta	1975	1985
Alpha Omicron Pi	1983	1986
Alpha Phi	1975	1984
Delta Gamma	1982	1987
Delta Zeta	1988	1989
Gamma Phi Beta	1975	1985
Kappa Alpha Theta	1984	1986

Centennial I complex (1965)

Congdon House. Dr. Wray H. Congdon served as dean of students, dean of the graduate school, and special assistant to the president. Alpha Phi sorority is housed in Congdon.

Emery House. It is named for Dr. Natt M. Emery, who was vice president and controller. Gamma Phi Beta sorority is housed in Emery.

Leavitt House. The Rev. Dr. John McD. Leavitt was the second president, 1875 to 1879. Alpha Gamma Delta sorority is housed in Leavitt.

McConn House. C. Maxwell McConn was dean of the university from 1923 to 1938. Alpha Omicron Pi sorority is housed in McConn.

Smiley House. Dr. E. Kenneth Smiley served as vice president from 1945 to 1964. Kappa Alpha Theta sorority is housed in Smiley.

Thornburg House. Dr. Charles G. Thornburg was professor and head of the department of mathematics, 1895 to 1923. His grandson, Dick Thornburgh, completed his second term as governor of Pennsylvania at the end of 1986. Delta Gamma sorority is housed in Thornburg.

Delta Zeta sorority is housed in the former Sigma Phi Epsilon fraternity house.

Alpha Chi Omega sorority is housed in the former Theta

Delta Chi fraternity house.

In Bethlehem, An Educational Tradition

Lehigh University shares in the historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer. The fact that Lehigh was established in Bethlehem reflects the tradition of education established by the community's first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects that came to the New World, and especially to Pennsylvania, during the early 1700s. But unlike William Penn, who established his *sylvania* as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians came as missionaries with the intent of converting the Indians to Christianity. For this purpose they settled the Lehigh Valley.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This building stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers and in continuous use ever since by the Moravian community. Many of these buildings are located on Church St., west of the City Center; industrial buildings are located in the 18th Century Industrial Area in the Monocacy Creek valley west of the business district.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He arrived in the settlement in time for their observance of Christmas Eve in 1741 and gave the settlement the name Bethlehem—"house of bread".

The settlers built high-quality structures of stone, demonstrating principles of engineering that were not generally used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church. In 1985, the 300th anniversary of the birth of Johann Sebastian Bach was observed.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying Moravian settlements, such as Nazareth, Pa., would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main St., a haven for travelers. Reconstruction of the picturesque inn was completed in 1982, and it now operates as a community center and public dining facility.

Zinzendorf's determination that Bethlehem would be a major industrial center was assisted by the completion in 1755 of the water works, the first public utility in the New World.

The Moravian dedication to education was an extension of the philosophy of John Amos Comenius, who had written, "Everyone ought to receive a universal education." The Moravian educational institutions that continue today, including Moravian College, stem from this tradition.

The Moravians, although avowedly opposed to war, found their community pressed into service as a hospital when Washington's troops bivouacked at Valley Forge during the winter of 1777-78. Washington came to the community once, and many other Continental Army officers were visitors.

The Sun Inn was also used as a hospital during the war; among its patients was an aristocratic renegade from France, Marie Joseph Paul Yves Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college in Easton was named in his honor and it became Lehigh's traditional football rival.

The first bridge across the Lehigh River was built in 1794. It was replaced in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte St. hill, was opened. The present Hill-to-Hill Bridge was built some fifty years ago.

"Black gold." During the late 18th Century, anthracite was found in the mountains north of the Lehigh Valley. In 1818, the Lehigh Coal Co. and the Lehigh Navigation Co. were formed, one to mine the anthracite on the upper Lehigh River, the other to transport it down river to metropolitan markets.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Mauch Chunk (now Jim Thorpe), through Bethlehem to Easton, where it connected with the Delaware Canal. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by coal, were in operation. Zinc ore, was found in neighboring Upper Saucon Township. In the 1850s Asa Packer built the Lehigh Valley Railroad. These origins eventually led to the heavy industry that continues in the Lehigh Valley today.

When Asa Packer founded Lehigh University in 1865, one of his objectives was to make possible broadly based education for young people of the region, combining the technical skills needed to run the flourishing industry of the Lehigh Valley with a liberal education.

In addition to its role as a steel-making center, Bethlehem today is a major tourist attraction. The Moravian community sets up an elaborate nativity scene and the entire city is decorated with lighting during the holiday period. The Moravian tradition of a single candle (now electric) in each window is widely observed.

Atop South Mountain is a steel tower known as the Star of Bethlehem. During the holiday period, the star's hundreds of bulbs create a 95-foot-high star that can be seen for many miles. The star was the gift to the community of Marion Brown Grace, wife of Eugene Gifford Grace, the steel magnate and president of the university board of trustees.

The community of Bethlehem has a population of approximately 78,000 persons with segments from a variety of nations who retain traditions of their country of origin.

There are five principal independent colleges in the Lehigh Valley besides Lehigh. They are Lafayette, Allentown College of St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained that allows cross-registration for courses as well as shared cultural events. There are also two community colleges in the area.

In August 1984, Bethlehem held its first Musikfest, a 10-day annual festival that features a variety of musical performances and ethnic foods. An instant success, Musikfest was the brainchild of Jeffrey A. Parks, a lawyer and 1970 Lehigh graduate.



VII.

Administration, Faculty and Staff

This section lists the people whose talents and abilities constitute the university's most important resource. Members of the board of trustees contribute their expertise to establish the policies of the university. Also listed are the administration, members of the faculty and staff, and the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

Board of Trustees

When the year of the degree is listed, the degree was awarded by Lehigh University.

Officers of the Board

William C. Hittinger, chair
John W. Woltjen, corporate secretary and treasurer
Richard H. Sanders, assistant treasurer
Robert M. Holcombe, executive secretary

Members of the Board

Dexter F. Baker, B.A. in M.E. '50, M.B.A. '57, Allentown, PA, chairman Executive Committee, Air Products and Chemicals Inc.
Curtis H. Barnette, J.D. Yale, Chairman & CEO, Bethlehem Steel
Patricia M. Battin, B.A., Swarthmore; M.S., Syracuse, Washington, DC, president, Commission on Preservation & Access
Charles W. Brown, Jr., B.S. in Economics '77, Leawood, KS, area sales manager, AT&T
Kevin L. Clayton, B.A. '84, M.B.A. St. Joseph's University, Investment Management, Trust Company of the West (NYC)
William L. Clayton, B.S. '51, Short Hills, NJ, senior vice president, Shearson, Lehman, Hutton, Inc.
Theodore L. Diamond, B.S. '37, M.B.A., New York City, president, T.L. Diamond Co., Inc.
John Diebold, B.S. Swarthmore, engineering degree U.S. Merchant Marine Academy, M.B.A. Harvard, New York City, NY, president and chairman, The JD Consulting Group, Inc.
William B. Eagleson, Jr., B.S. '49, M.B.A., Malvern, PA, retired chairman Emeritus, Mellon Bank Corp., Philadelphia
Herbert E. Ehlers, '62 B.A., '64 M.S., Bel Air, FL, president, Eagle Asset Management, Inc.
Phyllis A. Errico, '81 B.A., '84 J.D., Richmond, VA, assistant county attorney, County of Henrico, Richmond, VA
Murray H. Goodman, B.S. '48, chairman, The Goodman Company, Palm Beach, FL
William C. Hittinger, B.S. '44, Eng.D. '83, Summit, NJ, retired executive vice president, research and engineering, RCA Corp.
Ronald R. Hoffman, B.S. '54, Pittsburgh, PA, executive vice president, Human Resources, Aluminum Company of America.
Walter S. Holmes, Jr., B.S. '41, M.B.A., Ocean City, NJ,

retired chief executive officer and chairman, C.I.T. Financial Corp.

Douglas C. Lane, B.S. in Finance '67, M.B.A., University of Michigan, Cedar Grove, NJ, partner, investment counsel, Brundage Story & Rose

Peter Likins, university president/trustee ex officio.

Gina H. McBean, B.A. '82, Administrative Assistant to Lt. Governor, Senate of Pennsylvania

Eugene Mercy, Jr., B.S. '59, New York City, chairman, Granite Capital Group

James M. Miller, III, B.S. '65, M.B.A. '70, President, Argyle Capital Management

Diana T. Murray, B.A., Cornell, M.S., Columbia, New York, NY, vice president and treasurer, Academy of Political Science

Robert B. O'Brien, Jr., B.A. '57, Bernardsville, NJ, Printon, Kane Group, Inc.

Philip R. Peller, B.S. '60, Glen Head, NY, partner, Arthur Andersen & Co.

Joseph R. Perella, B.S. '64, M.B.A., New York City, partner, Wasserstein, Perella & Co., Inc., New York

John W. Puth, B.A. '52, J. W. Puth Associates

James R. Rice, B.S. '62, M.S. '63, Ph.D. '64, professor engineering science and geophysics dept., Harvard University, Cambridge, MA

Stanley M. Richman, B.S. '55, New Vernon, NJ, vice president, Lightning Electric Co.

C. Keith Rust, B.S. '57, Bethlehem, PA, president, Roland & Roland Inc.

Edwin F. Scheetz, Jr., B.S. '54, Pittsburgh, PA, chairman, Scheetz, Smith & Co., Inc.

Francis H. Spiegel, '57 B.S., '64 C.P.A., Lebanon, NJ, senior vice president, Merck & Co., Inc.

Donald B. Stabler, B.S. '30, M.S. '32, LL.D. '74, Harrisburg, PA, chairman, Stabler Companies Inc.

Karen L. Stuckey, B.S. '75, Partner, Audit, Price Waterhouse NYC

James B. Swenson, B.B.A. '59, Wellesley, MA, partner, Price Waterhouse.

Ronald J. Ulrich, B.S. '67, M.B.A., New York University, President, Equinox Capital Management

Ronald H. Vaughn, B.S. '59, West Chester, PA, President, NEAPCO.

Frank E. Walsh, Jr., '63 B.S., Chatham, NJ, vice chairman, Wesray Capital Corporation

Joseph F. Welch, B.S. '56, Wyomissing, PA, chairman, J.F. Welch Interests, Inc.

William E. Zeiter, B.A. '55, B.S. '56, J.D. '59, Philadelphia, PA, partner, Morgan, Lewis and Bockius.

Honorary Trustees

Morgan J. Cramer, '28, Center Valley, PA, retired president, P. Lorillard and Co.

Lee A. Iacocca, B.S. '45, M.S., LL.D., Eng.D. '69, Bloomfield Hills, Mich., retired chairman and chief executive officer, Chrysler Corp.

Robert H. Riley, Jr., B.S. '35, Towson, Md., retired director,

Black and Decker, Inc.

S. Murray Rust, Jr., B.S., in M.E. '34, Orleans, Mass., retired chairman of the board, Rust Engineering Co.

Corporate Members Emeriti

C. Lester Hogan, B.S., M.S. '47, Ph.D. '50, A.M., Eng.D., D.Sc., Eng.D. '71, Atherton, Calif., retired consultant to the president, Fairchild Camera and Instrument Corp.

Frank C. Rabold, B.S. '39, Eng. D. '70, Bethlehem, PA, retired manager of corporate services, Bethlehem Steel Corp.

The Rt. Rev. Dean T. Stevenson, B.A., '37, S.T.B., M.A. '49, D.D., Harrisburg, Pa., retired bishop of the Episcopal Diocese of Central Pennsylvania.

Committees of the Board

Executive committee. Mr. Hittinger, chair; the Messrs. Clayton, Eagleson, Mercy, Richman, Scheetz, and Stabler, members.

Academic affairs committee. Mr. Mercy, chair; Ms. Battin and the Messrs. Diamond, Diebold, Rice, Spiegel, Swenson, and Gina McBean, members.

Graduate Studies & Research Subcommittee. Ms. Battin and the Messrs. Diamond, Diebold and Rice, members.

Audit committee. Mr. Holmes, chair; Ms. Murray, Mr. Peller, and Ms. Stuckey, members.

Development committee. Mr. Stabler, chair; Mr. Clayton, vice chair; the Messrs. Baker, Diamond, Goodman, Mercy, Perella, Swenson, Vaughn, and Welch, members.

Finance committee. Mr. Eagleson, chair; the Messrs. Baker, Clayton, Holmes, Lane, Murray, O'Brien, Peller, and Perella, members.

Investment subcommittee. Mr. Lane, chair; the Messrs. Clayton, Francis, Perella, D. B. Salerno, Tschampion, Frank E. Walsh, Jr. and William D. Washychyn, members.

Nominating committee. Mr. Hittinger, chair; the Messrs. Baker, Eagleson, Michael G. Bolton and Donald H. Bott, members.

Physical planning and plant committee. Mr. Richman, chair; Mr. Rabold, vice chair; the Messrs. Goodman, Rust, Stabler, and Walsh, members.

Student affairs committee. Mr. Scheetz, chair; Mr. Hoffman, vice chair; the Messrs. Brown, Ehlers, Vaughn, Zeiter and Phyllis Errico, members.

Principal Officers

Educational information (degrees earned and colleges and universities attended) may be found in the alphabetical listing that follows in this section. The highest degree earned is given here.

All offices, unless otherwise noted, are located at Bethlehem, Pa. 18015; the area code, unless otherwise noted, is (215). (Please note that as of January 1, 1994, Lehigh's area code will change to 610).

Principal Officers

Peter Likins, Ph.D., president
758-3157

Alan W. Pense, Ph.D., provost and vice president for academic affairs
758-3605

John W. Woltjen, B.S., treasurer and vice president for administration
758-3178

Marsha A. Duncan, M.S., vice president for student affairs
758-3890

Michael G. Bolton, M.B.A., vice president for development and university relations
758-3121

Roy C. Herrenkohl, Ph.D., vice provost for research and dean of graduate studies
758-4210

Patti T. Ota, Ph.D., vice provost for academic administration and associate to the president
758-3165

James Schmotter, Ph.D., dean, College of Business and Economics
758-3402

Sunder H. Advani, Ph.D., dean, College of Engineering and Applied Science
758-5308

James D. Gunton, Ph.D., dean, College of Arts and Science
758-4570

Alden J. Moe, Ph.D., dean, College of Education
758-3221

Anthony L. Corallo, M.A., assistant vice president for facilities services and campus planning
758-3970

Richard W. Barsness, Ph.D., executive director, Iacocca Institute
758-5452

College Officers

College of Arts and Science

James D. Gunton, Ph.D., dean
Howard R. Whitecomb, Ph.D., associate dean
Julie Williams, Ph.D., associate dean
758-3300

College of Business and Economics

James W. Schmotter, Ph.D., dean
Therese A. Maskulka, D.B.A., associate dean
Kathleen A. Trexler, M.B.A., assistant dean and director, MBA program
758-3402

College of Engineering and Applied Science

Sunder H. Advani, Ph.D., dean
Ken N. Sawyers, Ph.D., associate dean
Harvey G. Stenger, Jr., Ph.D., associate dean
758-4025

College of Education

Alden J. Moe, Ph.D., dean
758-3221

Offices and Resources

In this section, only the principal officers, are listed. For degree information, consult the alphabetical listing that follows.

Administrative Systems

8B E. Packer Avenue; 758-3010
Roy A. Gruver, director

Admission

27 Memorial Drive, West; 758-3100
Patricia G. Boig, director

Alumni Association

27 Memorial Drive, West; 758-3135
Donald H. Bott, executive director

Art Galleries

17 Memorial Drive, East; 758-3615
Ricardo Viera, director

Athletics and Recreation

641 Taylor Street; 758-4300

Joseph D. Sterrett, director

Bookstore

9 W. Packer Avenue; 758-3375

Robert W. Bell, director

Budget

27 Memorial Drive, West; 758-4204

James A. Tiefenbrunn, director

Bursar

27 Memorial Drive, West; 758-3160

Craig Wood, bursar

Business Services

203 E. Packer Ave.; 758-3840

Barry L. Gaal, assistant vice president

Career Services

14 E. Packer Avenue; 758-3710

Marilyn Mackes, director

Mailing and Printing Services

118 ATLSS Drive; 758-5402-Mailing; 758-5408-Printing

Wayne S. Hoffman, director

Chaplaincy Services

36 University Drive; 758-3877

Rev. Dr. Lloyd H. Steffen, university chaplain and professor of religion studies

Community Relations

118 Research Drive; 758-3885

James W. Harper, director

Computing and Communication Services

30 Library Drive; 758-4750

Bruce D. Fritchman, assistant vice president

Computing Center

8B E. Packer Avenue; 758-3830

William R. Harris, director

Conference Services

63 University Drive; 758-5306

Jessica Dunlap, manager

Continuing, Distance and Summer Studies

36 University Drive; 758-3935; 758-3966

James A. Brown, director

Controller

27 Memorial Dr., West; 758-3140

Robert E. Siegfried, controller

Counseling Service

36 University Drive; 758-3880

Ian T. Birky, director

Office of Student Life

29 Trembley Drive; 758-4156

Mark H. Erickson, dean of student life

Terrence M. Curran, associate dean of student life

Jennifer F. Volchko, associate dean of student life

Development/University Relations

27 Memorial Dr., West; 758-3120

Michael G. Bolton, vice president for development and university relations

John T. Fulton, assistant vice president for development

Facilities Services

461 Webster St.; 758-3970

Anthony L. Corallo, assistant vice president for facilities services and campus planning

Gary A. Falasca, director of physical plant

Patricia A. Chase, director, physical planning

Financial Aid

218 W. Packer Avenue; 758-3181

William E. Stanford, director

Forum

29 Trembley Drive; 758-4190

Stacy Knudsen, co-chairperson; 882-2136

John H. Abel, co-chairperson; 758-5429

Fraternity Management Association

516 Brodhead Ave.; 758-3888

John J. Weaver, M.B.A., executive director

Health Center

36 University Drive; 758-3870

Stanley L. Yellin, M.D., director

Human Resources (Personnel)

428 Brodhead Ave.; 758-3900

Edward R. Maclosky, director

Institutional Purchasing

203 E. Packer Ave.; 758-3840

Joseph Hardenberg, manager

Internal Audit

27 Memorial Drive, West; 758-5012

Robert J. Eichenlaub, director

International Students and Scholars

5 E. Packer Avenue; 758-4859

Anne Thomas, coordinator

The Learning Center

33 Sayre Drive; 758-3098

Edward E. Lotto, director

Libraries

8A East Packer Avenue; 758-3025

Berry G. Richards, director

Lynn K. Milet, director of media services; 758-3058

Media Relations/Communications

436 Brodhead Ave.; 758-3171

Rita Malone, director of university communications

William Johnson, director of marketing communications

Microcomputer Store

524 Brodhead Ave.; 758-4606

Robert R. Kendi, manager

Personnel

(See Human Resources)

University Police

36 University Drive, Room 221; 758-4200

Eugene Dax, chief

Sports Information

641 Taylor Street; 758-3174
Glenn A. Hoffman, director

University Publications/Design

30 Library Drive; 758-3015
Marvin Simmons, director of design
Suzanne Kowitz, production director
Suzanne Gaugler, business manager

Registrar

27 Memorial Drive, West; 758-3200
Bruce S. Correll, registrar

Office of Research and Sponsored Programs

526 Brodhead Ave.; 758-3021
John M. Cheezum, Jr., director
Mary Jo Hill, associate director

Vice Provost for Research and Dean of Graduate Studies

5 E. Packer Avenue; 758-4210
Roy C. Herrenkohl, vice provost

Residential Services

63 University Drive; 758-3500
David M. Joseph, director

Risk Management

616 Brodhead Ave.; 758-3899
Thomas J. Verbonitz, director

Student Affairs

27 Memorial Drive, West; 758-3890
Marsha A. Duncan, vice president
John W. Smeaton, assistant vice president and dean of students
Joseph D. Sterrett, assistant vice president and director of athletics

Telecommunications

30 Library Drive; 758-3004
Roy Gruver, director
William A. Brichta, associate director of software support

Transportation Services

126 Goodman Drive; 758-4410
Christopher J. Christian, manager

Treasurer

27 Memorial Drive, West; 758-3180
John W. Woltjen, vice president for administration and treasurer
Richard H. Sanders, assistant vice president for financial services

Ben Franklin Advanced Technology Center

125 Goodman Drive, Bethlehem, Pa. 18015; (215) 758-5200
Mark S. Lang, executive director

Manufacturing Services Extension Center

301 Broadway, Bethlehem, Pa., 18015; (215) 758-5599
Edith D. Ritter, executive director

Faculty and Staff; Emeriti

The first date after the name is the date of appointment to continuous service on the Lehigh faculty or staff; the second

date, when the first fails to do so, indicates the date of appointment to the present professional rank. Where the name of the institution awarding a high-level degree is not given, the institution is the same one that awarded the previous degree listed.

P.E. indicates certification as a professional engineer; CPA indicates certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T.C., means certified athletic trainer.

A

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Thomas J. Addison (1992), Captain, USAF, Assistant Professor of Aerospace Studies. B.S., University of California at Davis, 1984; M.A., Webster University, 1991.
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- George D. Watkins (1975), Sherman Fairchild Professor of Solid-State Studies. B.S., Randolph-Macon, 1943; M.S., Harvard, 1947; Ph.D., 1952.
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- Ce-jun Wei (1989), research scientist, computer science and electrical engineering. M.S.M.E., Qing-Hua, 1962; Ph.D., Academia Sinica, 1966.
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Directors and staff members of the university's research centers and institutes are listed. Complete degree information may be found in the faculty and staff alphabetical listings. In some cases, areas of research interest are given.

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Building and Architectural Technology Institute

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621 Taylor Street; 758-3427

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Center for International Studies

9 W. Packer Avenue; 758-4745

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Center for Molecular Bioscience and Biotechnology

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Sherman Fairchild Center for Solid-State Studies

161 Memorial Drive, East; 758-3950, FAX 758-4561

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Small Business Development Center

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SMART (Science Model Area Resource Team) Center

Coppee Hall 309, 33 Coppee Drive; 758-3235

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Science, Technology and Society Program and Technology Studies Resource Center

9 W. Packer Avenue; 758-3550

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7 Asa Drive; 758-3570; 3600

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Research Scientists: Wayne Bilder, M.S.; Ming Gao, Ph.D.; Richard D. Granata, Ph.D.; Richard G. Herman, Ph.D.; Thomas Lloyd, Ph.D.; Alfred Miller, Ph.D.

Visiting Research Scientists: Emir Gurer, Qun Sun, Owen Feeley, Jih-Mirn Jehng, Roy Miron, Mahmoud Moussavi-Madani.

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In addition, it is essential to the progress of the university that the direction and quality of each unit be maintained. The regular visit of a group of highly qualified individuals from the outside provides both a stimulus for self-appraisal by a given department or division, and an objective view by an outside group of the work of that unit.

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Academic Calendar

The university academic calendar has evolved over the years to reflect the desires of students and faculty and the needs of the university as a whole.

Generally speaking, classes are scheduled only Monday through Friday. Typically, a three-credit-hour course is offered with either three fifty-minute class sessions Monday, Wednesday, and Friday morning, or with two seventy-five minute classes on Tuesday and Thursday morning. Afternoon classes Monday through Friday are scheduled in either fifty-minute or seventy-five minute segments.

Students should note that the fall semester concludes prior to the holiday vacation in December. To make this possible, classes commence at the end of August. In the spring semester, classes begin following the semester break, and conclude in mid-May.

While every effort has been made to include correct dates in the calendar that follows, the faculty or the University Forum may exercise their right to make changes.

Fall, 1993

August 25-26 (Wednesday-Thursday)—Graduate Registration
August 27-August 29 (Friday-Sunday)—Freshman Orientation, Freshman Registration
August 30 (Monday)—Undergraduate Registration
August 31 (Tuesday)—Classes begin, last day for graduate registration
September 1 (Wednesday)—Last day to file applications for Founder's Day degree
September 8 (Wednesday)—Last day for October doctoral degree candidates to deliver dissertation drafts to the dean of Graduate Studies
September 13 (Monday)—Last day for fall registration and adding courses; First Faculty meeting of the academic year
September 16-17 (Thursday-Friday)—Rosh Hashanah
September 20 (Monday)—Last day to select or cancel pass/fail grading
September 25 (Saturday)—Yom Kippur
September 29 (Wednesday)—Four o'clock quizzes; Last day for October master's candidates to submit unbound thesis copies to the dean of Graduate Studies
September 30-October 1 (Thursday-Friday)—Succoth
October 1 (Friday)—Last day for October doctoral candidates to complete all degree requirements
October 5 (Tuesday)—Four o'clock quizzes
October 6 (Wednesday)—Four o'clock quizzes
October 7 (Thursday)—Four o'clock quizzes
October 9-12 (Saturday-Tuesday)—Packing Break
October 10 (Sunday)—Founder's Day
October 13 (Wednesday)—Classes resume, Monday classes meet
October 18 (Monday)—Midsemester reports due
November 1-5 (Monday-Friday)—Preregistration for Spring, 1994
November 3 (Thursday)—Last day to withdraw from a course with a "W"
November 4 (Thursday)—Four o'clock quizzes
November 9 (Tuesday)—Four o'clock quizzes
November 10 (Wednesday)—Four o'clock quizzes
November 11 (Thursday)—Four o'clock quizzes

November 12 (Friday)—Last day for January doctoral degree candidates to deliver approved dissertation draft to Dean of Graduate Studies

November 25-28 (Thursday-Sunday)—Thanksgiving Vacation

November 29 (Monday)—Classes resume

December 1 (Wednesday)—Last day to file applications for conferred January degree

December 3 (Friday)—Last day for hourly exams

December 10 (Friday)—Last day of classes; Last day for January master's degree candidates to submit unbound thesis copies to the dean of Graduate Studies

December 11-12 (Saturday-Sunday)—Review-consultation-study period

December 13 (Monday)—Final exams begin; Last day for January doctoral degree candidates to complete all degree requirements

December 21 (Tuesday)—Final exams end

Spring, 1994

January 13-14 (Thursday-Friday)—Graduate Registration

January 16 (Sunday)—Commencement

January 17 (Monday)—Undergraduate Registration

January 18 (Tuesday)—Classes begin; last day for graduate registration

January 31 (Monday)—Last day for spring registration and adding courses

February 7 (Monday)—Last day to select or cancel pass/fail grading

February 16 (Wednesday)—Four o'clock quizzes

February 17 (Thursday)—Four o'clock quizzes

February 19-22 (Saturday-Tuesday)—Packing Break

February 23 (Wednesday)—Classes resume, Monday classes meet; Four o'clock quizzes

February 24 (Thursday)—Four o'clock quizzes

March 1 (Tuesday)—Last day for filing applications for June graduation

March 7 (Monday)—Midsemester reports due

March 23 (Wednesday)—Last day to withdraw from a course with a "W"

March 24 (Thursday)—Four o'clock quizzes

March 26-April 3 (Saturday-Sunday)—Spring Break

March 27-28 (Sunday-Monday)—Passover

April 1 (Friday)—Good Friday

April 4 (Monday)—Classes resume

April 5 (Tuesday)—Four o'clock quizzes

April 6 (Wednesday)—Four o'clock quizzes

April 7 (Thursday)—Four o'clock quizzes

April 11-15 (Monday-Friday)—Preregistration for Summer 1994 and Fall 1994

April 27 (Wednesday)—Last day for hourly exams

May 2 (Monday)—Last day for May doctoral candidates to deliver approved dissertation drafts to the dean of Graduate Studies

May 4 (Wednesday)—Last day of classes

May 5-7 (Thursday-Saturday)—Review-consultation-study period

May 9 (Monday)—Final examinations begin

May 18 (Wednesday)—Final examinations end; Last day for May master's candidates to submit unbound thesis copies to the dean of Graduate Studies

May 23 (Monday)—Last Day for May doctoral candidates to complete all degree requirements

May 29 (Sunday)—University Day

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